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# MULTIMAX: An Air Dispersion Modeling Program for Multiple Sources, Receptors, and Concentration Averages

Shell Development Co.
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# MULTIMAX: An Air Dispersion Modeling Program for Multiple Sources, Receptors, and Concentration Averages

J. H. Moser

August 1979

SHELL DEVELOPMENT COMPANY
A DIVISION OF SHELL OIL COMPANY
Westhollow Research Center
Houston, Texas
P.O. BOX 1380, HOUSTON, TEXAS 77001

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16. Abstracts
MULTIMAX computes highest and second highest 1-, 3-, 24-hour and annual nonreactive non-settling pollutant concentration averages from multiple stacks (up to 100) at arbitrary locations. The pollutant concentration averages for up to 300 receptors are calculated basis various modifications of the Gaussian plume model and a year's history of hourly-recorded meteorological data. Receptor numbers and locations (and heights, if used) are arbitrarily specified by the user. Default computing options produce same results as EPA's CRSTER model. Individual source contributions to each receptor can be printed. Program is designed to help satisfy modeling requirements of Clean Air Act of 1977. Univac 1100 series- and IBM 970 series-compatible versions of computer program are available.

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# FOREWORD

Since this manual was originally published in December of 1977, a number of developments have taken place which warrant a complete update; a number of typographical errors and omissions have been found in the original manual. In addition, a number of computing options have been added and certain default values have been changed.

The original computer program was developed on a Univac 1110 computer; a number of machine-dependent features of the software were utilized in order to attain maximum flexibility of the program from a user's standpoint. In 1978, the Tennessee Valley Authority, as represented by Messrs. T. C. Koss and J. W. Condrey (River Oaks Building, Muscle Shoals, Alabama 35660) modified the Univac 1110 version of MULTIMAX so that it would run on IBM 360/370 computers. The two versions of the program are now available through the National Technical Information Service. MULTIMAX is referenced in the EPA's Guideline on Air Quality Models (see Reference 14).

The major additions to this User's Manual are Appendices which discuss input formats for the IBM program version, certain machine-dependent features of the programs and show example inputs and outputs for the Univac and the IBM versions.

J. H. Moser
July 1977

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# MULTIMAX: AN AIR DISPERSION MODELING PROGRAM FOR MULTIPLE SOURCES, RECEPTORS AND CONCENTRATION AVERAGES

by

J. H. MOSER

## SYNOPSIS

Program "MULTIMAX" has been developed for the estimation of 1-, 3-, 24-hour and annual pollutant concentration averages by means of the latest, practical state-of-the-art in air dispersion modeling techniques. The Clean Air Act specifies standards in terms of ground-level pollutant concentrations based upon 3-, 24-hour and annual averaging periods. MULTIMAX estimates all of these desired values in one computer run for a number of emitting sources (current maximum = 100) at receptor locations (current maximum = 300) located on a grid system. In addition, individual source contributions to a given type of total average concentration at particular source locations are estimated.

The modeling basis for the program is the Gaussian Plume Model with the Briggs Plume Rise formulas applied to each of all possible source-receptor pairs for meteorological conditions assumed constant for one hour. For a particular receptor, the concentration contribution from each source is accumulated for the current hour and the desired averages accumulated for the input year's collection of hourly meteorological data. Modeling options include adjustment of the wind speed for the stack height relative to the observational height by means of a power law, adjustment of the concentrations from the 10 minute sampling basis used in the computations to a one-hour basis, "calibration" of the model results, *per se* by means of a linear equation

whose slope and intercept ("background") are input as well as several methods for estimating the effects of elevated terrain features.

The main types of program input are Meteorological data, the "Emissions Inventory" (source descriptions) and Receptor descriptions. Meteorological data is the same as required by EPA's CRSTER model. Representative years' histories of hourly meteorological data may be obtained from consultants or directly from the U.S. Government's National Climatic Center. The usual stack parameter data is input for each source with the locations being specified in Cartesian or polar coordinates optionally referenced to the Universal Transverse Mercator coordinate grid system. Receptors are individually specified in sufficient number and locations to adequately locate maximum concentrations; receptor heights above the stacks' base plane are optionally input. If the model is being applied to a plane situation, sets of receptors may be easily specified as points on circles, segments of circles or on straight lines. Required coordinate grid information is input as for the sources.

The primary program output consists of the following types of concentration averages for each receptor:

1. Annual,
2. Highest 3-hour running,
3. Second-highest 3-hour running (which does not overlap the highest),
4. Highest 24-hour (midnight - midnight),
5. Second highest 24-hour,
6. Highest 1-hour.

These values for each receptor are printed in descending order of concentration in a table for each type; one may specify that only the n highest values be printed. The maximum values information for each receptor may be output to a file for subsequent plotting or statistical analysis by other programs. Next, for each of highest of the above six quantities, the program automatically lists the concentration contribution of each source to the total at the particular receptor - time period combination. (Similar output may be manually specified for any receptor - time period combination.) The meteorological data for the days involved in the source contribution breakdown for the above six maxima types is listed. Optionally, the total concentration for each receptor for a manually-specified time period may be listed and output to a file; the latter can be used for subsequent contour plotting (the plotting routines have not been implemented as of this writing).

A number of special features have been designed into the program in order to facilitiate its use and to help avoid unnecessary operational errors. The entire input card deck (or file in card deck format) may be processed without starting the modeling calculations in order to check for detectable errors of ordering, omission, etc.; the diagnostics are as extensive as possible. In any event, the program does not allow the modeling calculations to commence if any input errors have been detected.

Currently, the program requires about 1.2 seconds of Univac 1110 Central Arithmetic Unit ("CAU") time for the year's computations for a single source - receptor combination. Thus the computations for 50 sources and 100 receptors requires about 100 minutes of CAU time. Therefore, the computations may be started during the day (N-priority*) and allowed to continue to the maximum time specified on the Run card (only 5 minutes maximum is allowed during prime time). MULTIMAX constantly checks for CAU time remaining in the run and when only 10 seconds are left, it saves the entire problem description, status and results to the current time in a file. The program estimates and prints the amount of CAU time required to complete the calculations basis the computational history to the current point in time. The user may then restart the program from where it stopped by means of a simple input deck running under "T" or "W" priority overnight when longer run times are allowed.

When a year's modeling computations are completed, MULTIMAX always saves the problem description and results on a mass storage file, which can be used in several ways. In order to better define the locations of maximum concentrations, receptors may be added to the system in any area. Then the year's computations for the maximum concentrations need only be performed for the added receptors, therefore saving much CAU time. Also, the sampling-time corrections and calibration equations are applied to the original modeling results only at final output (printing and/or filing) time, therefore they may be changed (if used) quickly and cheaply without repeating the lengthy modeling computations for the year. Also, the saved file may be used for additional listings or file generation without repeating the lengthy computations.

On an IBM 370/65, about 0.8 seconds of CPU time was required per source-receptor combination for a particular run. Some of this time difference is ascribable to the fact that the Univac version uses a formatted meteorological data file, the IBM uses an unformatted file. Also run times will vary with meteorological data sets and combinations of source-receptor locations. Note that the IBM-compatible version of the program does not have the "self-saving" features that the Univac version does, as described in the preceding paragraphs.

---

* On Shell computers the highest priority (and cost)is designated "H". The daytime, prime time priority is"N" and is lower in cost. Non-prime time priorities are "T" and "W" and are of yet lower costs, respectively.

Card image input and all printed output has been limited to a width of 80 characters and the program has options such that the amount of output can be minimized. Thus if a time-sharing link is available to the computer, the program may be completely operated from an 80 character-width terminal with no editing. This also allows the printed ouput to be appended to 8-1/2" by 11" reports without photoreduction.

## INTRODUCTION

The Clean Air Act[1)] promulgated air pollutant standards in terms of annual, 24-hour, and 3-hour average concentrations for sulfur dioxide and particulate matter. The National Ambient Air Quality Standards are specified in terms of the second highest ground level concentrations, maximized with respect to all possible receptor locations in the area. The regulations promulgated by the United States environmental Protection Agency (EPA) for prevention of significant deterioration of the air quality give the standards in terms of the highest ground level concentrations, maximized with respect to all possible receptor locations. Air dispersion computer modeling techniques are generally used to estimate such quantities because the designs of proposed emitting sources are being examined for their possibility of violating the standards, monitoring stations have not been installed or are too costly to install and/or if monitoring stations are installed, it would be impossible to position a sufficient number of them to define the yearly maxima because of the vagaries of the meteorological conditions over a whole year.

In the past, the EPA has accepted estimates of maximum annual concentration averages, using such modeling programs as the Air Quality Display Model (AQDM) and the Climatological Dispersion Model (CDM), both available from the EPA. These programs, based upon conditional probability distributions of meteorological conditions for a year, do not estimate the requisite short period averages mentioned above. Other modeling programs, such as PTMAX and PTDIS (available from the EPA) are applicable to short time periods with steady-state meteorological conditions and the concentration results are not readily extrapolatable to averages for time periods greater than about one hour. The EPA's PTMTP model may be used to calculate concentrations averaged for periods comprising 1 to 24 hours but the input "worst case" meteorology for each hour must somehow be selected externally to the model.

Also, the "worst case" meteorological conditions must be somehow externally selected for the latter type of programs.

MULTIMAX was developed in early 1977 to fill a specific need: Modeling of petroleum refinery - chemical plant complexes which contain a relatively large number of point sources located over a relatively large area. EPA's CRSTER model is applicable only to point sources all located at essentially the same geographical point. EPA's RAM model was not available at the time. Therefore, MULTIMAX was developed for these purposes and the EPA's precursor to CRSTER, "MAXT24", was used as the basic prototype for the calculations. A number of features have been incorporated into MULTIMAX which, it is believed, make it easy to use, flexible (with respect to computing options) and conservative of computer time. This computing program is specifically designed to satisfy the air dispersion modeling requirements for the Ambient Air Quality and Prevention of Significant Deterioration provisions of the Clean Air Act of 1977. Specifically, it is for the Sulfur Dioxide and Total Suspended Particulates requirements. (Note that geometric annual concentration averages are not calculated because there is no standard specification of the threshold concentration value to use in place of zero. The value of the geometric average critically depends upon the exact value of this threshold value.)

The original MULTIMAX (for MULTIple sources, receptors and concentration MAXima) program was developed on the Univac 1110 and was designed to take advantage of certain software features unique to the Shell installations of that machine. After release to the public, Messrs. Koss and Condrey of the TVA (see Foreword) modified the Univac version of the program so it would run on IBM 360 and 370 machines. Because of the limited capabilities of the applicable IBM software, a number of convenience features are not available in the IBM versions of the program. The most notable of these are the "self-saving" and ALL RECEPTORS operations of the Univac version (see Appendix I).

In developing this program, modeling techniques recommended or recognized by the EPA were used wherever possible. For example, the subroutines for Briggs plume rise and the Pasquill-Gifford dispersion parameters ($\sigma_y$ and $\sigma_x$) were taken from the EPA's UNAMAP package. Other techniques, such as the adjustment of the effective wind speed to the stack height and the algorithm for finding the source/receptor vs. wind azimuth angle difference for which the concentration is assumed to be zero were taken from the EPA's MAXT24 program. Options have been provided for some of the modeling calculations because their use may be controversial or so that these program results can be directly compared to those from other programs for credibility purposes.

This report is organized as follows: First, the technical basis of the program is discussed; this includes averaging methods and location of receptors, the dispersion model description and its options, meteorological data aspects, input/output requirements and special features. Secondly, selected MULTIMAX results are compared with other, EPA-accepted program results for the same data. Appendices I and II are detailed User's Guides for use of the program. Eight other appendices (see Table of Contents) have been included to facilitate the use of the program.

## OVERALL PROGRAM OPERATION

### Averaging Methods, Maxima and Location of Receptors

If it is assumed that meteorological conditions are constant for a given time period (say one hour) and that all dispersant emission sources in the area of interest operate constantly in the same time period, then, given a suitable mathematical air dispersion model (see later) the average concentration of dispersant for that time period at some spatial point (receptor location) can be estimated. If it is also assumed that the concentration estimates from the dispersion model operating on a single source-receptor combination are superimposable, then the concentration estimates from all sources for a given receptor may be computed separately and added to obtain the total average concentration at that receptor. This is done here to obtain the hourly average concentrations for all receptors specified. To obtain the annual average concentration for each receptor, the hourly values computed from input meteorological data for each hour of a representative year are summed and divided by the total number of hours in the year. Estimation of 24-hour averages is just as straightforward in that the EPA Guidelines for Interpretation of Air Quality Standards$^{2)}$ state that the time period is to be from midnight to midnight. This reference also states that the 3-hour averages are to be computed on a running basis. Contrary to these guidelines, the EPA CRSTER model does not compute the three-hour concentrations on a running basis; discrete, non-overlapping periods, starting at midnight for each day, are used therein.

The Federal Regulations (Reference 1) for Ambient Air Quality state that the appropriate standard "shall not be exceeded more than once per year".

Thus in comparing estimated maxiumum concentration averages, the highest one is to be disregarded and the second-highest one compared with the corresponding standard. If a very large number of receptor locations are specified for the area being modeled, it would appear that one should find the maximum concentration average for each receptor, then compare the second-highest of these with the standard. This is not the procedure to be employed according to the EPA Guidelines which is: For each receptor, retain the second-highest average concentration during the course of the calculations for the year (this requires that the highest be also saved). Then, after the year's calculations are completed, search the list of second-highest values for all receptors to find the maximum of these values; this is the second-highest maximum average concentration. This latter procedure is relatively straightforward to implement for the 24-hour concentration averages. However, computation of the second-highest maxima for the 3-hour concentration averages is somewhat more complicated because the averages are running. The Guidelines state that the time periods for the highest and second-highest concentration averages at each receptor are not to overlap. That is, a local maximum which is adjacent to a higher one within overlapping time periods is to be excluded. MULTIMAX computes the averages in these EPA-designated manners (some programs do not calculate running 3-hour averages, a day is merely divided into 8 periods).

Because of the very large number of calculations required for estimation of the various maxima (a problem with 50 sources and 100 receptors requires about 100 minutes of computer time), it is not feasible to have the program perform a search algorithm over the geographic area in question to find ground-level locations corresponding to these maxima. Also, for an area with significant terrain elevations, a complete topographical description of the area would have to be input; this is also impractical. Therefore, the proper use of the program requires judgment on the part of the user in selecting and adding receptor locations for sequential runs of the program. Thus, in the first use of the program for estimating the maximum concentrations for an area, the user should probably specify 4 or 5 concentric rings of receptors. After the results are obtained for these, it will probably be found (because of the wind persistency) that the receptor locations for all the maxima (possibly excepting the 1-hour average) lie within a sector of the compass rose. The user can then add receptors to the problem definition and rerun the program with a finer grid of the sector in order to better define the locations of the maxima. An important feature of the Univac version of MULTIMAX is that only the computations for the added receptors need be performed; results are output for all receptors thus conserving computer time.

The EPA often requests that source and receptor locations be reported in Universal Transverse Mercator (UTM) coordinates. The user may optionally input locations in UTM or coordinates referencing a local origin. The coordinates of the local origin also may be specified in UTM coordinates, in which case the UTM coordintes will be output. See Appendix V for information on the UTM system and how to obtain topographical maps for the area to be studied.

## Overall Sequence of Operations

The normal sequence of operations is as follows: After input of data and control cards (or card image records, see last page of Appendix I for an example) the program proceeds to find the six types of maximum concentration averages for each receptor for the year's history of meteorological data; these are called the "Yearly Maxima" computations. If, during the course of these calculations it is found that insufficient Univac Central Arithmetic Unit (CAU) time remains for the computer run, the problem definition, status and all results to date are saved on the SAVE file from which the computations can be started from that point in a subsequent computer run. When the yearly maxima computations have been completed for the year, the same information is always written to the SAVE file. Next, the PRINT routine is called to sort the results for each type of average in descending order of concentration for the receptors, perform the sampling time adjustments and apply the "calibration" equation to the results if so required (see later) and print the results. These results may be also output to the formatted RESULTS file for future use by the Univac computer. An example output page is shown in Figure 1. The PRINT routine also tabulates the type of concentration average, the receptor number and the applicable time period data for the six maxima values for use in subsequent operations.

With the information available (preceding sentence), the program then calculates and prints the concentration contribution of each source to each of the receptor for the given time periods. Figure 2 is an example of this output. These are termed the "Source Contribution" calculations. The meteorological data for the given days tabulated is optionally output. These Source Contribution calculations may be suppressed, which may be desirable for the first few runs of a problem. Alternatively, the Yearly Maxima computations may be bypassed and the Source Contributions calculations only performed. In this case, the average type - receptor number - time period specifications are input on cards.

```
 MULTIMAX EXAMPLE CASE 1

MULTIMAX AIR DISPERSION PROGRAM            SHELL OIL COMPANY
                                      RUN STARTED:   3 MAR 1977        8:20:32

PROBLEM TITLE:

 EXAMPLE CASE FOR TESTING OF PROGRAM MULTIMAX.

SECOND HIGHEST 3-HOUR AVERAGE CONCENTRATION FOR EACH RECEPTOR

   (IN DESCENDING ORDER)

 RANK    RECEPTOR   UG/M**3,   DAY    HOUR
  1          3       671.6     157     13
  2          4       599.5     153      8
  3          5       554.5     292     12
  4         11       514.2     274     11
  5          1       506.1      70     11
  6          9       498.9     264      9
  7         12       488.8     103     20
  8          8       477.1      51     13
  9          6       448.5     278      9
 10          7       431.5      10      2
 11         24       417.3     300      3
 12         10       404.7       5      6
 13         32       359.2      39     21
 14         27       354.9     101      5
 15         28       341.0     176     22
 16         19       338.6     167      6
 17          2       303.1     132      9
 18         34       301.9     265      7
 19         29       296.0     285      7
 20         26       283.9     109      1
 21         30       258.8     328      3
 22         35       247.8     111     23
 23         18       227.4     171      2
 24         17       218.5     200     22
 25         22       216.6     340     24
 26         16       215.2     227     18
 27         25       214.8      22      1
 28         13       203.3     227      2
 29         23       187.2     361     23
 30         14       185.8     227      7
 31         31       180.9     283     18
 32         20       174.6     282     23
 33         15       163.1     146      6
 34         21       158.9     283     19
 35         33       155.4     238      3
```

**Figure 1: Example of Yearly Maxima Results**

```
   MULTIMAX EXAMPLE CASE 1

MULTIMAX AIR DISPERSION PROGRAM              SHELL OIL COMPANY
                                        RUN STARTED:   3 MAR 1977        8:20:32

PROBLEM TITLE:

 EXAMPLE CASE FOR TESTING OF PROGRAM MULTIMAX.

RECEPTOR     3  3-HOUR AVERAGE CONCENTRATION=  671.6
                DAY = 157 HOUR = 13

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E         NO.     PERCENT.     UG/M**3      RANK
SECOND STACK              2     100.00       671.6          1
CENTER STACK              1      .0000       .0000          2
```

Figure 2. Example Source Contribution Results

Finally, and again using the tabular information on the six maxima from the PRINT routine, the program calculates and prints the total dispersant concentration average for each type of average for all receptors. Figure 3 is an example of this output type. These results may be added to the formatted RESULTS file. If not done previously, the meteorological data for the given days may be printed. These "ALL Receptors - Selected Time Period" calculations may be suppressed. Alternatively, these calculations may be initiated without either the Yearly Maxima or Source Contribution calculations having been performed; in this case the average type - time period specifications are input directly from cards.

The Source Contribution calculations and/or the All Receptor - Selected Time period calculations may be initiated without reading in the source and receptor definition cards if the problem definition has been already written to the SAVE file.

If the yearly maxima results have been recorded in the Univac SAVE file, all the above may be repetitively printed out (by input of PRINT RESULTS cards) without repeating the lengthy Yearly Maxima computations. This feature may be also used to differently apply the sampling time correction and calibration equation options without repeating the lengthy Yearly Maxima computations. If a "RESULTS" file is specified in the FILES paragraph, it will also be output.

```
MULTIMAX EXAMPLE CASE 1

MULTIMAX AIR DISPERSION PROGRAM              SHELL OIL COMPANY
                                      RUN STARTED:   3 MAR 1977        8:20:32

PROBLEM TITLE:

 EXAMPLE CASE FOR TESTING OF PROGRAM MULTIMAX.

  3-HOUR AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 157 AND HOUR 13


                              --- REFERRED TO LOCAL ORIGIN ---------- UNIV. TRANS. MERC.
REC. RANK  UG/M**3             X,KM      Y,KM    AZIMUTH  RADIUS,KM     X,KM      Y,KM
  1   18  .0000                .000     1.200       .00      1.200    50.000    61.200
  2   19  .0000                .600     1.039     30.00      1.200    50.600    61.039
  3    1  671.6               1.039      .600     60.00      1.200    51.039    60.600
  4    2  341.3               1.200      .000     90.00      1.200    51.200    60.000
  5    4  203.5               1.039     -.600    120.00      1.200    51.039    59.400
  6    5  42.87                .600    -1.039    150.00      1.200    50.600    58.961
  7    3  338.7                .000    -1.200    180.00      1.200    50.000    58.800
  8    9  .3844               -.600    -1.039    210.00      1.200    49.400    58.961
  9   16  .3117-12           -1.039     -.600    240.00      1.200    48.961    59.400
 10   20  .0000              -1.200     -.000    270.00      1.200    48.800    60.000
 11   21  .0000              -1.039      .600    300.00      1.200    48.961    60.600
 12   22  .0000               -.600     1.039    330.00      1.200    49.400    61.039
 13   23  .0000                .430     8.047      3.06      8.058    50.430    68.047
 14   24  .0000                .912     9.847      5.29      9.889    50.912    69.847
 15   25  .0000               2.230    11.165     11.30     11.385    52.230    71.165
 16   26  .0000               4.030    11.647     19.09     12.325    54.030    71.647
 17   27  .0000               5.830    11.165     27.57     12.595    55.830    71.165
 18   28  .0000               7.148     9.847     35.97     12.168    57.148    69.847
 19   29  .0000               7.630     8.047     43.48     11.089    57.630    68.047
 20    7  7.872               -.877    -8.492    185.90      8.537    49.123    51.508
 21    8  2.834              -1.931   -11.038    189.93     11.205    48.069    48.962
 22   10  .6455-01           -4.477   -12.092    200.32     12.894    45.523    47.908
 23   13  .1032-04           -7.023   -11.038    212.47     13.082    42.977    48.962
 24   14  .6520-11           -8.077    -8.492    223.57     11.720    41.923    51.508
 25   30  .0000              -6.954     3.067    293.80      7.600    43.046    63.067
 26   31  .0000              -5.060     5.746    318.63      7.657    44.940    65.746
 27   32  .0000              -3.167     8.425    339.40      9.001    46.833    68.425
 28   33  .0000              -6.759    -2.758    247.80      7.300    43.241    57.242
 29   17  .1123-12           -4.762    -4.191    228.64      6.344    45.238    55.809
 30   11  .1600-01           -2.764    -5.625    206.17      6.267    47.236    54.375
 31    6  9.510               -.767    -7.058    186.20      7.100    49.233    52.942
 32   34  .0000               7.247     4.441     58.50      8.499    57.247    64.441
 33   12  .3753-04            6.802    -6.343    133.00      9.300    56.802    53.657
 34   15  .3178-11           -6.905    -6.954    224.80      9.800    43.095    53.046
 35   35  .0000              -6.961     4.521    303.00      8.300    43.039    64.521
```

**Figure 3: Example of all Receptor - Selected Time Period Results**

# MATHEMATICAL MODEL DESCRIPTION

## Geometrical Considerations

For a single solution of the Gaussian Plume Model, the downwind and crosswind distance of the receptor from the source with respect to the plume centerline are required. Given the Cartesian coordinates of the source ($X_s$, $Y_s$) and the receptor ($X_r$,$Y_r$), the coordinate system may be translated such that the source is the new origin*:

$$X = X_r - X_s \qquad (1a)$$

$$Y = Y_r - Y_s \qquad (1b)$$

where the absence of the subscript indicates the receptor coordinates with respect to the source, Then,

$$\beta = \tan^{-1}(Y/X) \qquad (2)$$

$$\text{If } X < 0,\ \alpha = 270° - \beta \qquad (3)$$

$$\text{Otherwise, } \alpha = 90° - \beta \qquad (4)$$

As shown in Figure 4, $\alpha$ is the clockwise azimuth angle from North for the line between the source and receptor.

The angle, $\theta$, between the source-receptor line and the wind (plume centerline) is found by:

$$\theta' = |\alpha - \gamma| \qquad (5a)$$

where $\gamma$ is the azimuth angle, clockwise from North, towards which the wind is blowing (this is the value input from the meteorological data file for the hour).

$$\text{If } \theta' < \gamma,\ \text{use } \theta = \theta' \qquad (5b)$$

$$\text{If } \theta' \geq \gamma,\ \text{calculate } \theta'' = 360 - \theta' \qquad (5c)$$

$$\text{Then if } \theta'' < \gamma,\ \text{use } \theta = \theta'' \qquad (5d)$$

---

*The symbols are described following the References.

Otherwise, assume that the pollutant concentration is zero. To conserve computing time, if the absolute value of the receptor - plume centerline angle ($\theta$) is greater than a value $\lambda$ which depends upon the Pasquill atmospheric stability class (stab) then the pollutant concentration at the receptor is assumed to be zero. Table 1 shows these exclusion angles:

---

## TABLE 1

RECEPTOR - WIND ANGLES FOR ASSUMPTION OF ZERO CONCENTRATION

| Stability (Class) (stab) | Exclusion Angle Degrees $\lambda$ (stab) |
|---|---|
| 1 | 50 |
| 2 | 50 |
| 3 | 40 |
| 4 | 30 |
| 5 | 20 |
| 6 | 20 |

---

(This technique is used in EPA's CRSTER program.)

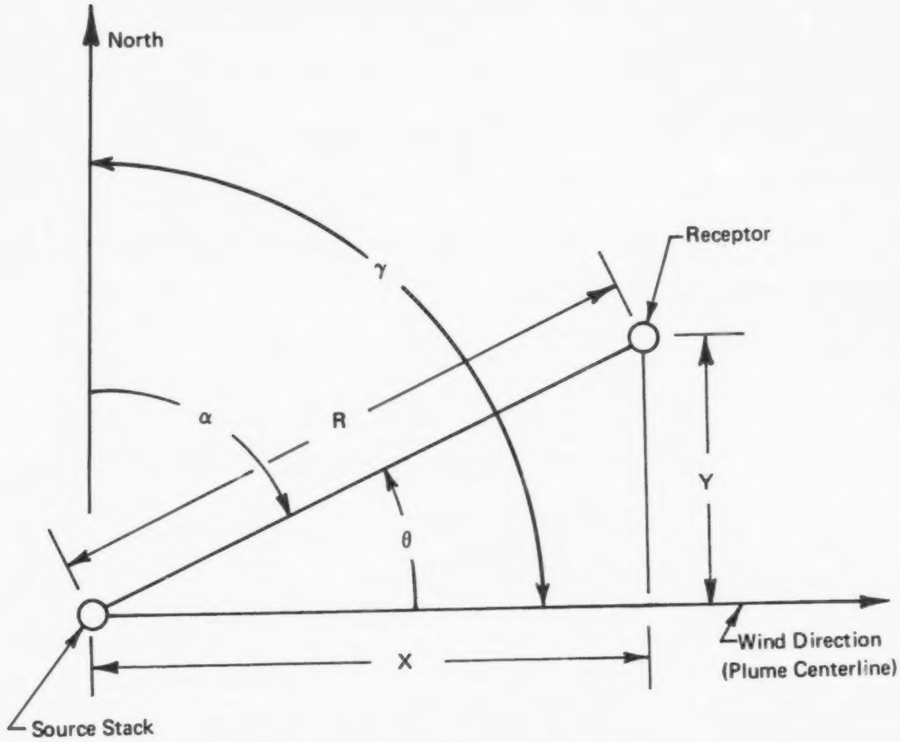
Therefore, if $\theta \leq \lambda$, the program proceeds to calculate the pollutant concentration at the receptor, $\chi$, finding the receptor coordinates with respect to the plume path by:

$$R = (Y^2 + X^2)^{1/2} \quad (6)$$

$$x = R*\cos(\theta) \quad (7)$$

$$y = R*\sin(\theta) \quad (8)$$

See figure 4.


North
γ
Receptor
α
R
Y
θ
X
Wind Direction
(Plume Centerline)
Source Stack

(The Vertical z Coordinate is Perpendicular to the Stack Base Plane Above)

**Figure 4. Coordinate Reference System for Diffusion Equation**

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## Adjustment of Wind Speed for Stack Height

It is generally observed that up to the altitudes under consideration in dispersion modeling, the wind speed increases monotonically with distance above the ground. The relationship used in the CRSTER model, based upon the work of DeMarrais[3], and used here is:

```
u = AWS* [(HS/WSOH)**P(stab)]                (9)
```

(Fortran notation)

In equation 9, AWS is the average wind speed as read from the meteorological data file for the hour, HS is the physical stack height, WSOH is the height at which the AWS was observed and P is an exponent which depends on stability class as shown in Table 3.

---

TABLE 3

EFFECTIVE WIND SPEED EXPONENT VS. STABILITY CLASS

| Stability Class (stab) | Exponent P (stab) |
|---|---|
| 1 | 0.10 |
| 2 | 0.15 |
| 3 | 0.20 |
| 4 | 0.25 |
| 5 | 0.30 |
| 6 | 0.30 |

---

The default value for WSOH in the program is 7.0 meters, which is the most common value for data obtained from the National Climatic Center. However, other observational heights are used and should be checked (see Appendix IV).

The effective wind speed, u, is then used in the plume rise and diffusion equation calculations. Optionally, this adjustment may be bypassed in which case u = AWS. Note that some programs, such as EPA's PTMAX, PTDIS and PTMTP as well as Shell's SMOGII, do not use this adjustment algorithm; therefore u = AWS for those programs.

## Plume Rise Calculation

The widely-accepted Briggs Plume Rise formulas[4,5,6] are used to calculate the rise of the plume centerline above the stack top at the downwind distance from the source, x. For non-flare stacks, the buoyancy flux parameter is calculated by:

$$F = \frac{gV}{\pi}\left(\frac{T_s - T}{T_s}\right) \qquad (10)$$

For flare (burning) stacks, use:

$$F = 0.037q \qquad (11)$$

Next, for unstable or neutral conditions [classes 1 - 4 (or A - D)], calculate

$$x^* = 14\ F^{5/8} \quad \text{for } F < 55 \qquad (12)$$

or

$$x^* = 34\ F^{2/5} \quad \text{for } F \geq 55 \qquad (13)$$

The distance to the final rise is:

$$x_f = 3.5\ x^* \qquad (14)$$

If x, the downwind distance to the receptor is less than $x_f$, calculate the plume rise at x by:

$$\Delta H = \frac{1.6F^{1/3}\ x^{2/3}}{u} \qquad (15)$$

For distances greater than or equal to $x_f$, use $x_f$ in place of x in equation 15 to find the rise.

For stable conditions [classes 5 and 6 (E and F)], calculate

$$\rho = g \frac{\partial T/\partial z}{T} \qquad (16)$$

The temperature slope with respect to altitude, $\partial T/\partial z$, is assumed to be 0.02°K/M for stability 5 and 0.035 for stability class 6. (Most EPA programs assume these same default values.) The plume rise is then calculated as follows:

Calculate

$$\Delta H_1 = 2.4\left(\frac{F}{u\rho}\right)^{1/3} \qquad (17a)$$

and

$$\Delta H_2 = \frac{5F^{1/4}}{\rho^{3/8}} \qquad (17b)$$

Set $\Delta H_f$, the final stable plume rise, to the lesser of $\Delta H_1$ and $\Delta H_2$.

The distance to final rise under stable conditions is:

$$x_f = \frac{3.14u}{\rho^{1/2}} \qquad (17c)$$

For the "superstable" class 7 (G) it is assumed the plume goes straight up and therefore the ground concentration of pollutant is zero. This condition is tested by the program before any calculations are made for the given hour.

The effective plume height used for the diffusion equations is then

$$H = \Delta H + HS \tag{18}$$

If H is greater than the mixing layer height, L, the program assumes the ground level concentration of dispersant is zero.

Both the Univac and IBM versions of the program normally use the computed plume height at the downwind distance of the source from the receptor for the dispersion calculations. However, the IBM version has an option wherein the final plume rise only is used for all calculations.

## Diffusion Equations

The "classical" Gaussian Plume diffusion equation is

$$\chi = \frac{Q}{2\pi u \sigma_y \sigma_z} * \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] * \left\{ \exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \right.$$

$$\exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right] + \sum_{N=1}^{\infty} \left\langle \exp\left[-\frac{1}{2}\left(\frac{z-H-2NL}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H-2NL}{\sigma_z}\right)^2\right] + \right.$$

$$\left. \left. \exp\left[-\frac{1}{2}\left(\frac{z-H+2NL}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H+2NL}{\sigma_z}\right)^2\right] \right\rangle \right\} \tag{19}$$

This equation is that numbered 5.8 in Turner's Workbook[11] multiplied by the exponential term involving y which correctly accounts for the receptor being away the perpendicular distance y from the plume centerline. This steady-state equation assumes a constant wind flux over a plane upon which the stack base rests. A receptor, located a perpendicular distance z above the plane, is assumed not to disturb or influence the wind field. See Figure 4 for illustration of the x and y coordinates for the receptor location. The dispersion parameters, $\sigma_y$ and $\sigma_z$, are functions of the downwind distance, x, and the atmospheric stability class. Program MULTIMAX uses subroutine SIGMA, originally written by D. B. Turner, for the calculation of these two dispersion parameters (the subroutine was modified only to remove the call arguments, placing them in COMMON, in order to increase the computational speed). This subroutine returns the same values as presented graphically in Figures 3-2 and 3-3 of the Workbook in which it is stated (page 6): "For the parameter values given here, the sampling time is assumed to be about 10 minutes, ...". The terms in equation 19 following the summation operator are often called the "reflection terms". This series converges very rapidly; for a mixing layer height, L, greater than about 5 $\sigma_z$, one evaluation (N = 1) generally suffices.

The diffusion equation 19 is applied downwind until it can be assumed that sufficient vertical mixing between the ground and the mixing layer has occurred so that the dispersant concentration is uniform in the vertical direction. That is, if $\sigma z/L < 1.6$, use equation 19, otherwise use the equation for "trapping" conditions:

$$\chi = \frac{Q}{\sqrt{2\pi}\,\sigma_y\,uL} * \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \qquad (20)$$

MULTIMAX uses equation 19 by default for which $H$, the effective plume height, is used directly from the Briggs plume rise formulas presented above.

If the receptor height, $z$, is set equal to zero, equation 19 reduces to:

$$\chi = \frac{Q}{2\pi\ \sigma_y\ \sigma_z} * \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] * \left\{ 2*\exp\left[-\frac{1}{2}\left(\frac{H*}{\sigma_z}\right)^2\right] + \sum_{N=1}^{\infty} \left\langle 2*\exp\left[-\frac{1}{2}\left(\frac{H*-2NL}{\sigma_z}\right)^2\right] + 2*\exp\left[-\frac{1}{2}\left(\frac{H*+2NL}{\sigma_z}\right)^2\right] \right\rangle \right. \tag{21}$$

If the MULTIMX user declares that all receptors are on the stack base plane level ( option ), then equation 21 is used instead of equation 19 because the former requires only about half the number of computations and the results are identical. For this, $H^* = H$. Of course, equation 20 is still used for trapping conditions, $\sigma_x/L \geq 1.6$.

## Terrain Effects

If the area for which the dispersion calculations are being made is hilly, then one might be tempted to use the elevation of the receptor location on a hill above the stack base lane as $z$ in equation 19 to estimate the dispersant concentration. This implies that if the plume centerline height is equal to or close to the receptor elevation at the downwind position of the receptor, then the plume passes through the hill. Therefore this usage of $z$, should only be used if the receptor is located on a structure that does not significantly disturb the wind field. Also, if $\underline{z}$ is negative (the receptor is in a valley), the use of the dispersion equation becomes meaningless, especially if one considers the true air flow patterns that could exist. Therefore, for all methods of "handling" non-plane terrain, MULTIMAX limits $\underline{z}$ used in the diffusion equations to zero or positive values.

Egan[8] presented a thorough analysis of this problem on the basis of fluid dynamic theoretical considerations and the results of extensive field monitoring/modeling studies. He concluded that for flow over terrain features approximating hemicylinders laying on a plain, a plume centerline should not approach the elevations any closer than roughly one-half of the plume height. He also summarized experimental data which showed that observed ground level concentrations on hilly terrain are very much lower than would be predicted with a Gaussian Plume model. Thus it appears that as a first approximation, one might treat an elevated terrain receptor point by using some fraction of the actual height of the point, $z_{in}$, for the value of $\underline{z}$ in equation 19 and to limit the latter to one-half of the effective plume height, $\underline{H}$. The whole subject of complex terrain effects in practical air dispersion modeling is currently under intense discussion and investigation.

The EPA uses a "tall stack" approximation to the classical Gaussian Plume equation in certain of their modeling programs, namely the CRSTER[13] (but not in program PTMTP). This modeling approach is also often referred to as the "terrain adjusted model" and operates as follows:

$$\text{Let } H^* = H - z \qquad (22)$$

then use H* in equation 21 if trapping conditions do not exist, otherwise, use equation 20. This model may be pictured as lowering the stack into the ground by a distance $z$, then saying the receptor is at the stack base plane level. Note that the inversion height, $L$, is not tampered with.

If the effective plume height $H$ (from the Briggs' equations) is very much greater than the receptor height, $z$, then this approximation gives essentially the same results as the classical equation 19 and requires only about half as much computer time. However, as the value of $z$ approaches the value of $H$, then the concentration calculated by equation 21 approaches twice the concentration calculated from equation 19. This may be shown as follows: Substitute equation 22 into equation 21 and divide the result by equation 19. For large mixing layer height $L$, one obtains:

$$C = \frac{2*\exp\,[-(H'-z')^2]}{(\exp\,[-(H'-z')^2] + \exp\,[-(H'+z')^2])} \qquad (23)$$

$$\text{where } H' = H/\sigma_z \qquad (24)$$

$$z' = z/\sigma_z \qquad (25)$$

Equations 24 and 25 normalize the effective plume height, $H$, and the effective receptor height, z_, such that the properties of the concentration ratio, $C$, can be more easily studied. For equation 23, if $z = 0$, then $C = 1$; thus identical results are obtained by either calculational method. If $z' = h'$, then equation 23 reduces to

$$C = \frac{2}{1 + \exp[-(2H')^2]} \qquad (26)$$

Then, as H' tends to zero, C tends to 1; therefore concentrations calculated by either method for emitters and receptors near the stack base plane level will be the same. On the other hand, as H' = z' becomes large, C by equation 23 approaches a value of 2 in the limit in which the tall stack approximation will give concentration values twice as high as the classical plume equation. Figure 5 shows the behavior of C as a function of z' and H'. Note that z' does not have to become very large with respect to zero for C to deviate appreciably from the value of 1.

A "validation" study[9] was sponsored by the EPA which attempted to establish the validity of the CRSTER version of the MAXT24 model (same as the "tall stack approximation" here). Based on a year's collection of continuous $SO_2$ monitoring data in the vicinity of three power plants in the Ohio River valley, those authors more or less concluded that that model adequately predicted ground-level concentrations for two of the plants. These had stack heights of 244 and 251 meters with effective plume heights estimated by this author to be at least 400 meters. On the other hand, for the third plant with stack heights of about 80 meters and effective plume heights estimated here to be at least 100 meters, the authors of that report stated: "The treatment of terrain effects used by the model was found to be inapplicable for those receptor locations with elevation near stack height." In addition, examination of the predicted vs. observed results summarized in the EPA report suggests that the concentrations would have been better predicted for the last, "short stack" plant by using the classical form of the Gaussian Plume model (equation 19) instead of the tall stack approximation.

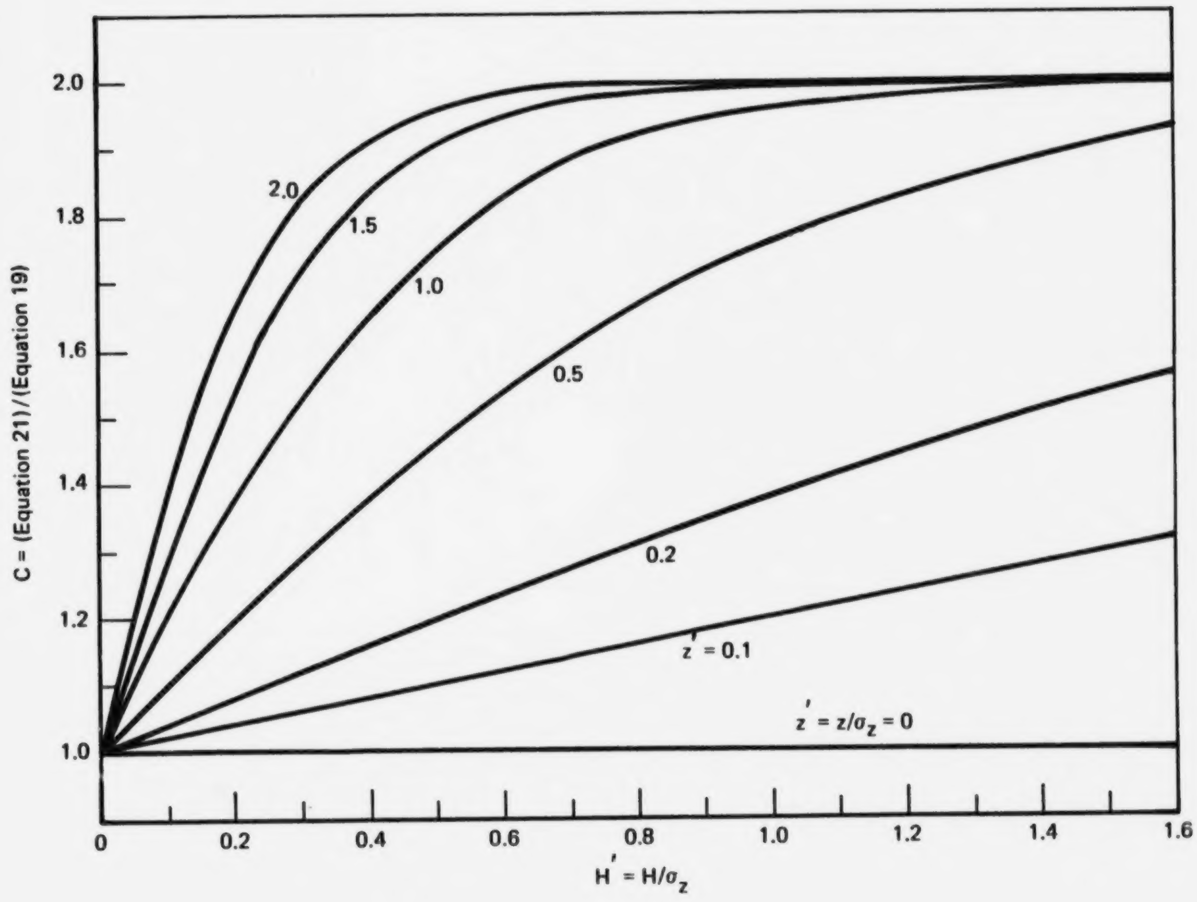

Figure 5. Comparison of Tall Stack vs Full Form of Diffusion Equations

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In the solution of the differential equations to obtain the Gaussian Plume model, it was assumed that a constant wind field with no vertical velocity gradients moved over a plane and that any receptor elevated above the plane are points which do not disturb the wind field. Therefore, use of this classical form (equation 19) for any other terrain or receptor situation must be viewed as an empirical approximation. Since no definitive experimental data is yet available, the question remains as to what would be the best set of options to use. Let us define an effective receptor height, z', which when used in the Classical form of the diffusion equation results in correct concentration estimates for receptors located on the surface of elevated terrain. Thus for a particular receptor, for a given plume path and with a mixing height low enough so that the "reflection" terms in the plume equation become significant, MULTIMAX should give good estimates of the desired extreme values. However, if the tall stack approximation is used, the ground and mixing layer planes' usage in the reflection terms (equation 21) becomes very difficult to interpret and the results will be different than for the Classical equation case. The picture with respect to the tall stack approximation becomes even more confusing for the case of multiple stacks of various heights and plume rise values. In addition, a discontinuity will be encountered with the tall stack approximation if trapping conditions (equation 20) are estimated at large downwind distances. For these reasons and in accordance with the discussion illustrated by Figure 5, use of the Classical equation 19 is recommended over the tall stack approximation, equations 21 and 22.

How should the effective receptor height, z', be calculated? It is fairly well accepted that the use of $z' = z_{in}$ leads to high concentration values because a plume is actually deflected upwards by some amount over hills. Use of $z' = 0$ causes estimation of too low concentrations because the deflection causes increased turbulence and mixing. The proper value of $z'$ would be a complex function of meteorological conditions, topography, surface roughness, etc. Therefore, for simplicity and lacking the definition of this complex function, a very rough first approximation to the true effective receptor height may be taken as half the actual terrain height ($z_{in}$) above the stack base plane.

In several modeling studies for permit applications and/or rulemaking, the EPA has used, or allowed the use of half the actual terrain height above the stack base plane as the effective receptor height input to the tall stack approximation of the plume model. They also limited the effective receptor height to the physical stack height; this is a necessary artifice because otherwise, with the effective receptor heights greater than that of the stack, the plume would be effectively emitted from below the ground level. The concentrations calculated from equation 31 would then be erroneously high. In any case, this combination of options can be used in the MULTIMAX Program so that EPA results can be estimated and/or if that usage is required. This effective receptor height treatment is called "MOD1".

$$\text{MOD1:} \quad z = z_{in}/2; \quad z \leq HS - 10 \text{ meters} \qquad (27)$$

However, it seems that this effective receptor height limitation, when used with the Classical form of the diffusion equation, should lead to too low concentration estimates when the actual terrain heights greatly exceed the physical stack height. Therefore, the effective receptor height should be limited to some small value; this may be arbitrarily set at 10 meters below the effective plume centerline height for "MOD2":

$$\text{MOD2:} \quad z = z_{in}/2; \quad z \leq H - 10 \text{ meters} \qquad (28)$$

This usage may be interpreted by saying that the closest approach of the plume centerline is not less than 10 meters to the effective height of a terrain feature.

With all available information being considered, it is the recommendation of this author that, unless the user is otherwise constrained, the best estimates will be made by use of the Classical form of the Gaussian Plume equation. If elevated terrain is involved in the study, the receptors elevations should be treated according to the MOD 2 formula. In any case, several options are available for treating non-plane terrain heights. The receptor height treatment available in the EPA CRSTER model has purposely been omitted for the following reason: The CRSTER model uses the "tall stack approximation" for the Gaussian plume model, and, if the user inputs a receptor height greater than a physical stack height, the EPA program "errors-off" the computer. This appears to be a statement of policy, for if one inputs a receptor height slightly less than the physical stack height, would not the concentration estimations be just as invalid?

## Sampling Time Correction

As mentioned above, the dispersion parameters used in the diffusion equations are mostly based on a ten minute sampling period. Turner[7] recommends the following relationship be used to adjust the concentration results basis one sampling period length, $t_k$ to another period length, $t_s$:

$$\chi_s = \chi_k \left( \frac{t_K}{t_s} \right)^{0.2} \tag{29}$$

Optionally, MULTIMAX applies equation 29 to the concentrations calculated by either equations 19 or 21; by default the adjustment is not made. For the values of $t_k = 10$ and $t_s = 60$ minutes used, the factor for $\chi_k$ is 0.6988.

Programs PTMAX, PTDIS, PTMTP and MAXT24 output concentration results on the uncorrected, 10 minute sampling time basis.

"Calibration" Equation

Sometimes it is desirable to apply the linear equation

$$\chi = A\chi_{mod} + B \tag{30}$$

to the concentrations, $\chi_{mod}$, calculated from the modeling equations discussed above. It may be desired to add a "background" concentration value B to all MULTIMAX concentration estimates. Alternatively, the slope, A, and background may be available from linear regression estimates based on experimental observations vs. model-predicted concentrations.

Equation 30 may optionally be used in MULTIMAX; $\chi_{mod}$ will have been already corrected for sampling time if so specified.

Note that the calibration equation and the sampling time correction are applied after the Yearly Maxima calculations, so if those results are on a Univac SAVE file, these options may be separately invoked with a PRINT, SELECTED CONTRIBUTIONS or ALL RECEPTORS - SELECTED TIMES operation of the program without repeating the lengthy Yearly Maxima computations.

This calibration quation may also be used to change all source emission rates by a factor A, because the source emission rate, Q, in equations 19, 20 and 21 is a multiplier.

## Meteorological Data Requirements

For each hour of a representative year, the modeling equations require atmospheric stability class number, wind speed, wind azimuth, ambient temperature and mixing layer height. The data should also be representative of the geographical area being modeled.

"Raw" meteorological data is available from the National Climatic Center (NCC) of the U.S. Department of Commerce's National Oceanic and Atmospheric Administration for all United States observation as well as many in other parts of the world. However, that data must be processed to obtain the stability class number and interpolate mixing heights (generally only available as a twice-daily observations) to produce the hourly values required by MULTIMAX. Since the wind direction observations are recorded only to the nearest ten degrees, the meteorological data processor also adds a random number between -5 and +5 to the observed values.

We have found it expedient to use the services of several consulting firms for this data processing. See Appendix IV for further details.

For many locations, hourly surface observation data is available for several years, notably 1964. However, mixing height data is available only for selected locations. For example, it was necessary to use Muskegon, Michigan surface observation data with mixing height data from Green Bay, Wisconsin for modeling an area near Traverse City, Michigan. It is advisable to check with the regulatory agencies concerned before the meteorological data is obtained for a particular modeling application.

The MET DATA PRINT feature of MULTIMAX allows a whole meteorological data file to be printed.

A wind persistency index, W, is printed with the meteorological data for the days for which maximum average concentrations are found. This index is calculated as follows:

$$h = \sum_{i=1}^{24} u_i \sin \alpha_i \tag{31}$$

$$v = \sum_{i=1}^{24} u_i \cos \alpha_i \tag{32}$$

$$\bar{u} = \left(\sum_{i=1}^{24} u_i\right)/24 \tag{33}$$

where i = hour number

then,

$$W = (h^2 + v^2)^{1/2}/\bar{u}$$

Thus W will range from a value of zero for complete randomness to a value of one for the wind blowing constantly in one direction for a 24 hour period.

Modeling Accuracy Estimates

For short sampling periods (10 minutes to an hour), it is generally estimated that the Gaussian Plume model, per se, when applied to flat plains, may estimate actual concentrations within the rough range of -1/2 to + 2 times the nominal value calculated about 70 percent of the time. The range to include about 90 percent of the values is about -1/3 to + 3 times the calculated value. These estimates are for short time period averages.

However, MULTIMAX estimates extreme values, which depend upon the representativeness of the year's history of meteorological data as well as the accuracy of the Plume Model. Thus the accuracies of MULTIMAX concentration estimates very difficult to quantitatively predict; the estimates may be said to be representative. One measure of accuracy is provided by the Monte Carlo studies of Neustadter and Sidik[10] for the second highest, 24-hour average concentration for a year. Using log-normally distributed population, their studies indicated that 95 percent of such values for all years should be within the range of 58 percent of the 365-day, sample-estimated value. This uncertainty value of 58 percent could be applied to MULTIMAX only if the dispersion model, per se, is errorless. Therefore, since the plume model is not without error, the uncertainties in the extreme values for concentration averages will be somewhat higher.

Lacking further information, the same uncertainty estimates might be roughly applied to the highest 24-hour and the 3-hour highest and second highest concentrations found by MULTIMAX.

Regulating agencies often consider the concentration results from modeling programs deterministic and use those extreme values in emission rate "rollback" calculational procedures.

## COMPARISON OF MULTIMAX RESULTS WITH OTHER PROGRAMS' RESULTS

In order to enhance the credibility of dispersion modeling results from MULTIMAX with respect to established EPA programs, two sets of comparisons were performed:

Program PTMTP from the EPA's UNAMAP package is a multiple source, multiple receptor air dispersion modeling program employing the classical diffusion equation with Briggs plume rise formulas. For a given set of source and receptor definitions, up to 24 sets of meteorological conditions can be input. Ouput consists of source concentration contributions to each receptor for each hour as well as the average concentrations for the number of hours of meteorological data specified. PTMTP makes no sampling time correction to the concentration calculations based upon the "10-minute" dispersion parameters as found in Turner's Workbook.[7]

For this comparison, ten receptor locations were selected downwind of two sources; the source parameters are presented in Table 4. Meteorological conditions for one steady-state "hour" were as shown in Table 5; these correspond to Day 118, Hour 9 on the MULTIMAX meteorological data file NEWORLEANS* LOUISIANA. Both program PTMTP (on the IBM 370) and MULTIMAX (on the Univac 1110 computer) were run with this data as input (modeling options are summarized in Table 13). (The "SELECTED SOURCE CONTRIBUTIONS" control feature was used with MULTIMAX.) Receptor locations and their concentration results are presented in Table 6. The results from both programs agree very well with each other; the small differences are ascribable to different truncation errors of the two computers.

---

## TABLE 4

### SOURCE PARAMETERS FOR PTMTP VS MULTIMAX COMPARISON

| Parameter | Stack 1 | Stack 2 |
|---|---|---|
| Height, m | 50.0 | 30.0 |
| Diameter, m | 1.5 | 2.0 |
| Emission rate, g/s | 300.0 | 50.0 |
| Gas velocity, m/s | 20.0 | 12.0 |
| Gas temperature, °K | 450.0 | 500.0 |
| Grid coordinates (x,y), km | 0,0 | 0.5,0.5 |

---

## TABLE 5

### METEOROLOGICAL CONDITIONS FOR PTMTP VS MULTIMAX COMPARISON

| Condition | Value |
|---|---|
| Stability Class | 3 |
| Wind Speed, m/s | 4.12 |
| Temperature, °K | 299. |
| Wind Azimuth, Degrees (direction to) | 2.[1] |
| Wind Direction (direction from) | 182.[2] |

[1] Input to MULTIMAX
[2] Input to PTMTP

---

## TABLE 6

## COMPARISON OF PTMTP VS. MULTIMAX RESULTS

| No. | Receptor Coordinates, m |  | μg/m$^3$ by PTMTP from stack: |  |  | μg/m$^3$ by MULTIMAX from stack: |  |  |
|---|---|---|---|---|---|---|---|---|
|  | x | y | 1 | 2 | Total | 1 | 2 | Total |
| 1 | -5,000 | 10,000 | 0.714E-07 | .1424E-10 | 0.714E-07 | .722E-07 | .1444E-10 | .723E-07 |
| 2 | -4,000 | 5,000 | 0.1746E-17 | 0 | 0.1746E-17 | 0[1] | 0[1] | 0 |
| 3 | -1,000 | 10,000 | 61.8 | 2.7 | 64.5 | 62.0 | 2.7 | 64.7 |
| 4 | 0 | 10,000 | 220.1 | 23.9 | 244.0 | 220.2 | 23.9 | 244.1 |
| 5 | 0 | 6,000 | 350.4 | 24.2 | 374.6 | 350.6 | 24.3 | 374.9 |
| 6 | 0 | 2,000 | 872.3 | 0.14 | 872.4 | 872.1 | 0.14 | 872.2 |
| 7 | 1,000 | 10,000 | 176.0 | 41.1 | 217.0 | 175.8 | 41.0 | 216.8 |
| 8 | 2,000 | 7,000 | 4.70 | 4.54 | 9.24 | 4.69 | 4.53 | 9.21 |
| 9 | 5,000 | 10,000 | .406E-04 | .450E-04 | .857E-04 | .447E-04 | .403E-04 | .850E-04 |
| 10[2] | 82.0 | 2,309 | 864.8 | 3.7 | 868.5 | 864.1 | 3.7 | 867.8 |

---

[1] Source/Receptor *vs.* wind angle greater than value in Table 1.

[2] This point is near the maximum ground level concentration.

These results establish the valididy of the basic "1-hour" model used in MULTIMAX (subroutine MODEL) which is used in all modeling calculations.

As a check on MULTIMAX' bookkeeping operations with respect to yearly averages, computer runs were made with identical input to both program MAX-24 and MULTIMAX. MAX-24 (or MAXT24) was the precursor to EPA's CRSTER model; the computations are identical. The comparative results from those two programs are summarized in Table 7; the slight differences are again ascribable to truncation error differences.

For the MULTIMAX vs. MAX-24 comparison, the parameters for the single source are as presented in Table 8. Three concentric circles of receptors on the stack base plane were selected with radii of 1.13, 2.18 and 7.04 kilometers, respectively. On each circle, receptors were located at 10° intervals, starting from North (0°). A meteorological data file containing hourly observations for the year 1964, surface observations for New Orleans, Louisiana and mixing layer heights for Lake Charles, Louisiana, was especially prepared for us by a consultant from National Climatic Center data. Selected results from both programs for annual, 24-hour and 1-hour concentration averages are presented in Tables 9 through 12 and the modeling options are summarized in Table 13. No 3-hour average concentration results are shown because they were not calculated by our version of the MAX-24 program. Results are presented only for the ten highest values found for each type of concentration average. The very slight differences between the corresponding results from the programs (both programs run on the Univac 1110) are probably caused by truncation and rounding errors, for the order and number of calculational steps are not the same in both programs.

---

TABLE 7

COMPARISON OF AUTHOR'S WITH EPA'S
MAX-24 RESULTS FOR MARIETTA PLANT

| Type of Concentration Average | Concentration, μg/m$^3$ | |
|---|---|---|
| | Author | EPA |
| Highest 24-hour | 801.8 | 801.9 |
| Second Highest 24-hour | 631.3 | 630.1 |
| Highest annual | 49.94 | 49.94 |
| Highest hourly | 3523.0 | 3529.0 |

MAX-24 Calculation Options Used:

1. Tall Stack form of plume equation.
2. Receptor height limited to physical stack height.
3. Sampling time not corrected to one hour.
4. Windspeed adjusted to stack height basis 7.0 m observation height.
5. Rural mixing heights.

## TABLE 8

### SOURCE PARAMETERS FOR MAX-24 VS. MULTIMAX COMPARISON

| Parameter | Value |
|---|---|
| Height, m | 45.72 |
| Diameter, m | 1.68 |
| Emission rate, g/s | 357.68 |
| Gas velocity, m/s | 19.1 |
| Gas temperature, °K | 459. |

## TABLE 9

### MAX-24 VS MULTIMAX: TEN HIGHEST 24-HOUR AVERAGE CONCENTRATIONS

| | μg/m$^3$ from: | | Receptor | | Julian |
|---|---|---|---|---|---|
| Rank | MAX-24 | MULTIMAX | Range, km | Azimuth,° | day |
| 1 | 178.2 | 178.0 | 1.13 | 60 | 193 |
| 2 | 175.0 | 174.8 | 2.18 | 340 | 92 |
| 3 | 165.6 | 165.5 | 1.13 | 220 | 186 |
| 4 | 162.3 | 162.2 | 1.13 | 240 | 265 |
| 5 | 157.7 | 157.5 | 1.13 | 40 | 117 |
| 6 | 154.7 | 154.6 | 1.13 | 230 | 138 |
| 7 | 154.5 | 154.4 | 1.13 | 50 | 223 |
| 8 | 147.3 | 147.2 | 2.18 | 240 | 275 |
| 9 | 145.6 | 145.5 | 2.18 | 60 | 193 |
| 10 | 142.3 | 142.2 | 2.18 | 250 | 35 |

## TABLE 10

### MAX-24 VS. MULTIMAX: TEN HIGHEST 24-HOUR AVERAGE CONCENTRATIONS

| | $\mu g/m^3$ from: | | Receptor | | Julian |
|---|---|---|---|---|---|
| Rank | MAX-24 | MULTIMAX | Range, km | Azimuth, ° | day |
| 1 | 178.2 | 178.0 | 1.13 | 60 | 193 |
| 2 | 175.0 | 174.8 | 2.18 | 340 | 92 |
| 3 | 165.6 | 165.5 | 1.13 | 220 | 186 |
| 4 | 162.3 | 162.2 | 1.13 | 240 | 265 |
| 5 | 157.7 | 157.5 | 1.13 | 40 | 117 |
| 6 | 154.7 | 154.6 | 1.13 | 230 | 138 |
| 7 | 154.5 | 154.4 | 1.13 | 50 | 223 |
| 8 | 147.3 | 147.2 | 2.18 | 240 | 275 |
| 9 | 145.6 | 145.5 | 2.18 | 60 | 193 |
| 10 | 142.3 | 142.2 | 2.18 | 250 | 35 |

## TABLE 11

### MAX-24 VS. MULTIMAX: TEN SECOND-HIGHEST 24-HOUR AVERAGE CONCENTRATIONS

| | μg/m$^3$ | from: | Receptor | | Julian |
|---|---|---|---|---|---|
| Rank | MAX-24 | MULTIMAX | Range, km | Azimuth, ° | day |
| 1 | 156.0 | 155.9 | 1.13 | 220 | 207 |
| 2 | 152.1 | 152.0 | 1.13 | 240 | 123 |
| 3 | 148.8 | 148.7 | 1.13 | 230 | 199 |
| 4 | 142.5 | 142.4 | 2.18 | 340 | 67 |
| 5 | 141.4 | 141.3 | 2.18 | 240 | 34 |
| 6 | 134.7 | 134.6 | 1.13 | 40 | 223 |
| 7 | 130. | 129.9 | 2.18 | 180 | 278 |
| 9 | 121.9 | 121.8 | 1.13 | 200 | 256 |
| 10 | 117.6 | 117.5 | 1.13 | 190 | 336 |

## TABLE 12

MAX-24 VS. MULTIMAX: TEN HIGHEST 1-HOUR AVERAGE CONCENTRATIONS

| | μg/m$^3$ | from: | Receptor | | Julian | |
|---|---|---|---|---|---|---|
| Rank | MAX-24 | MULTIMAX | Range,kr | Azimuth,° | day | Hour |
| 1 | 1075. | 1074. | 1.13 | 170 | 196 | 17 |
| 2 | 1058. | 1057. | 1.13 | 240 | 196 | 13 |
| 3 | 1041. | 1040. | 1.13 | 330 | 196 | 11 |
| 4 | 939.3 | 938.5 | 1.13 | 160 | 196 | 17 |
| 5 | 913.9 | 913.2 | 2.18 | 150 | 236 | 8 |
| 6 | 910.5 | 909.7 | 2.18 | 230 | 211 | 8 |
| 7 | 908.1 | 907.4 | 2.18 | 160 | 232 | 8 |
| 8 | 873.2 | 872.5 | 2.18 | 90 | 195 | 9 |
| 9 | 863.4 | 862.7 | 2.18 | 240 | 259 | 8 |
| 10 | 853.2 | 852.5 | 2.18 | 130 | 173 | 8 |

Note that it is (and was) not possible to compare 3-hour average concentration averages between MULTIMAX and CRSTER, for the former uses running averages as recommended by Guidelines whereas CRSTER does not.

## CONCLUSIONS

Program MULTIMAX has been developed to provide the environmental specialist with the latest, practical technology for estimating air pollutant concentration maxima in accordance with the National Ambient Air Quality Standards as well as the maxima specified by the Prevention of Significant Deterioration standards for sulfur dioxide and suspended particulate matter. A prime consideration in design of the program was that it be easy-to-use. Also, as changes in modeling concepts and averaging periods are required (say for different pollutants than those mentioned above) the new "options" should be easy to add to the program, as long as the basic model is of the Gaussian Plume form. In this line, a "news" facility has been provided for the Univac version so that a user can immediately ascertain if any addition or modifications have been made to the program.

# REFERENCES

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## NOMENCLATURE

| Symbol | Description | Units |
|---|---|---|
| A | Coefficient in calibration equation 30 | |
| AWS | Average wind speed at WSOH meters above ground | m/s |
| B | "Background" - intercept in calibration equation | $\mu g/m^3$ |
| C | Ratio of Equation 21 to Equation 19 | |
| F | Bouyancy flux parometer | $m^4/sec^3$ |
| g | Gravitation constant = 980 | $m/sec^2$ |
| H | Effective plume height | meters |
| H* | Modified plume height (Equation 21) | meters |
| $\Delta H$ | Plume rise | meters |
| HS | Physical stack height | meters |
| h | Horizontal wind persistence vector | m/sec |
| k | Sampling period designator | |
| L | Mixing layer height | meters |
| N | Summation index for diffusion equation | |
| P | Exponent in Equation 10 | |
| P | Probability of occurrence (statistical) | |
| Q | Source emission rate | g/sec |
| q | Flare stack heating rate | kcal/sec |
| R | Receptor range from stack | km |
| Stab | Pasquill stability class | -- |
| $T_s$ | Stack gas exit temperature | °k |
| T | Ambient temperature | °k |

| Symbol | Description | Units |
|---|---|---|
| $t$ | Sampling time (Equation 29) | minutes |
| $t_p$ | Student's t distribution value | |
| $u$ | Wind speed | m/sec |
| $V$ | Volumetric flow rate of gas exiting stack | $m^3$/sec |
| $v$ | Vertical wind persistence vector | m/sec |
| $W$ | Wind persistence parameter | |
| WSOH | Wind speed observational height | m |
| $X$ | Abscissa for point on grid system | km |
| $x$ | Downwind distance of receptor from stack | km |
| $x_f$ | Distance to final plume rise | meters |
| $Y$ | Ordinate for point on grid system | km |
| $y$ | Crosswind distance to receptor from plume centerline | meters |
| $z$ | Effective receptor height above stack base plane | meters |
| $Z_{in}$ | Input receptor height | meters |
| Greek Alphabet | | |
| $\alpha$ | Azimuth angle of stack-receptor line with respect to North | degrees |
| $\beta$ | Interim angle for calculations of X | degrees |
| $\gamma$ | Wind azimuth angle | degrees |
| $\lambda$ | Receptor-plume centerline exclusion angle for Concentration calculation | |
| $\Delta$ | Difference operator | |
| $\Theta$ | Angle between plume centerline and stack-receptor line | degrees |
| $\rho$ | Intermediate variable in Briggs Plume Rise calculations | |
| $\sigma_y$ | Horizontal dispersion parameter for diffusion equation | meters |
| $\sigma_z$ | Vertical dispersion parameter for plume equation | meters |
| $\chi$ | Dispersant concentration | $\mu g/m^3$ |

| Symbol | Description | Units |
|---|---|---|
| Superscripts | | |
| ' | Indicates normalized variable with respect to $\sigma_z$ | |
| ' | Temporarily used value of a variable | |
| - | (Overbar) - indicates average value | |
| * | Modified effective plume height (Equation 6) | |
| Subscripts | | |
| in | Input value | |
| k | Base sampling time | |
| mod | Predicted by model with no adjustment | |
| obs | Experimentally observed value | |
| P | Probability level | |
| r | receptor | |
| s | Source | |
| s | New sampling time basis | |
| stab | Pasquill stability class | |
| Units of Measure, Miscellaneous | | |
| km | Kilometers | |
| m | Meters | |
| s | Seconds | |
| wt | Weight | |
| μg | Micrograms | |
| * | Multiplication operator | |
| ** | Exponentiation operator | |

# APPENDIX I

## UNIVAC COMPUTER USER'S GUIDE FOR PROGRAM MULTIMAX

## FOREWORD TO APPENDIX I

Following is the program user's guide for preparation of input to the version of MULTIMAX as implemented on Shell Univac 1110 computers. Implementation of the program on other computers may necessitate some variances which should be described locally. Appendix II is the user's guide for the IBM 360/370 version of the program as prepared by the Tennessee Valley Authority personnel from the Univac version. Appendix VIII briefly discusses certain machine-dependent features of both versions.

Complete examples of the input run stream and the concomitant results are presented in Appendices IX and X.

## APPENDIX I

## USER'S GUIDE FOR PROGRAM MULTIMAX (UNIVAC VERSION)

### Introduction

The calculations performed by MULTIMAX consist of three main types:

A. For a year's input of hourly meteorological data, calculation of the maxima over all receptors for these six concentration averages:
   1. Highest annual
   2. Highest 24-hour
   3. Second highest 24-hour
   4. Highest 3-hour
   5. Second highest 3-hour
   6. Highest 1-hour

   (These will be referred to as "Yearly Maxima".)

B. For each of the values found in the preceding, the concentration contribution to each average is calculated for the given time period; these are referred to as the "Source Contribution" calculations.

C. For each of the Yearly Maxima concentration averages, excepting the annual, the average concentration at each receptor for the time period found for the yearly maximum value. These will be referred to as the "All Receptor - Selected Times" calculations.

After input of the data (excepting the meteorological data which is selected from a separate "MET" file during the course of the calculations), the program will automatically perform each of the above three types of calculations in the order shown. However, the performance of B and C may be suppressed or performed separately with the concentration averages type-time periods specified manually. Please refer to the main text for discussions of the various modeling options.

During the course of the Yearly Maxima calculations, the CAU time remaining is continuously monitored; if it is found that less than 10 seconds remain, the entire problem definition, status and all results to that point are saved on the SAVE file and the program stops. The computations may be subsequently RESTARTed from that point. When the Yearly Maxima computations have been completed for the year, the entire problem definition, status and all results are always saved on the SAVE file. The SAVE file is in binary form and cannot be externally accessed. However, the user can specify additional output of results on a formatted RESULTS file, which may then be input to other programs.

### Input Data Conventions

Input data, excepting meteorological, may be input to the Univac 1110 by means of an actual card deck via the remote batch terminals or as a card image file via the CMS timesharing computer Batch Link Interface.* To avoid ambiguity, all single-line, 80 character input records will be referred to as "cards". The card deck or input file of card images will be called the "deck".

The input deck may be considered to be composed of single control cards and groups of cards which are termed "paragraphs". The overall layout of the input deck is summarized in Table I.1, which is followed by detailed descriptions of the cards. A listing of an example input deck is included at the end of this Appendix.

Throughout the descriptions, literal symbols are shown by being all-capitalized; cards are always punched with the first symbol starting in column 1. The symbol'@' denotes a 7/8 punch in column 1 for Univac 1110 EXEC-10 operating system control cards.[11]

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* Shell computers only.

## TABLE I.1

## ORDERING OF INPUT DECK FOR PROGRAM MULTIMAX

| Input Control Cards | References |
|---|---|
| @Run, etc. | Page 58 |
| @ASG, etc. (two or more) | Page 58 |
| @USE, etc. (two or more) | Page 58 |
| @HDG, etc. (optional) | Page 59 |
| @DO MULMAX | Page 59 |
| NEWS | Page 59 |
| FILES | Page 59 |
| (insert cards) | (see Table I.2) |
| END | |
| IDENTIFICATION | Page 59 |
| (insert cards) | |
| END | |
| OPTIONS | Page 60 |
| (insert cards) | (see Table I.3) |
| END | |
| DATA | Page 60 |
| ORIGIN, etc. | Page 60 |
| SOURCES | Page 60 |
| (insert cards) | (see Table I.4) |
| ENDEND | |
| RECEPTORS | Page 61 |
| (insert cards) | (see Table I.5) |
| END | |
| START | Page 61 |

| | |
|---|---|
| RESTART | Page 61 |
| PRINT RESULTS | Page 61 |
| PRINT MET FILE | Page 62 |
| PRINT MET STATISTICS ONLY | Page 62 |
| SELECTED SOURCE CONTRIBUTIONS | Page 62 |
| (insert cards) | (see Table I.6) |
| END | |
| STOP | Page 62 |
| @FIN | Page 62 |

## DETAILED DESCRIPTION OF INPUT DATA DECK

(see also Appendix III, "Hints on Program Use")

| Card Contents | Explanation |
|---|---|
| @RUN, etc. | Standard Univac 1110 RUN card (see EXEC-10 User's Manual.)[11] |
| @ASG, Options FILENAME, ETC. | One file assignment control card is required for each mass storage file specified in the FILES paragraph following. "FILENAME" is the user-assigned EXEC-10 name for the file and the options as well as the information following the FILENAME depend on the type of mass storage (disc or tape) and whether the file (if disc) has been assigned in a previous run.<br>For example, suppose one wishes to establish a disc file named "EXAMPLE*PROB1-SAVE". The @ASG card could then be:<br>`@ASG,PU EXAMPLE*PROB1-SAVE,F2/1/TRK/200`<br>If this file had been established in a previous run, then the @ASG card should be:<br>`@ASG,AX EXAMPLE*PROB1-SAVE`<br>Use @ASG,A MET*FILENAME for the meteorological data file, for example. |
| @USE n,FILENAME | The EXEC-10 USE card establishes the correspondence between the logical unit number ("LUN") = n for FORTRAN input/output and the FILENAME from an ASG card. The value of n must be the same as that specified in the files paragraph for the unit. |

For the example above, suppose that 17 is the value of n arbitrarily selected for the SAVE file in the FILES paragraph below. Then the USE card would be:

```
@USE 17,EXAMPLE*PROB1-SAVE
```

The value of n.0 for LUN SAVE in the FILES paragraph is then 17.0.

| | |
|---|---|
| @HDG (title) | This optional card may be used to print a problem title or description at the top of each output page following. The pages will also be numbered on the far right of a 17 inch wide sheet. Leave at least one blank between @HDG and the title and do not use any periods in the title. |
| @DO MULMAX | This causes program MULTIMAX to be executed for Shell users. A @XQT card may be required in other installations. |
| NEWS | This optional card causes the latest information concerning program changes, modifications, etc. and support personnel to be printed. It should be input only once on first use of the program. No further input except the STOP and @FIN cards is required. |
| FILES | This card delineates the input of the FILES paragraph and must always be input for every run. See <u>Table I.2</u> for description of the LUN definition cards which follow the FILES card. Note that the SAVE and MET LUN cards must always be input. |
| (insert cards) | |
| END | Terminates the FILES paragraph. |
| IDENTIFICATION | Signifies the beginning of the descriptive problem identification paragraph. Follow with from 1 to 20 cards, each containing up to 80 characters of descriptive information. |
| (insert cards) | |
| END | Terminates the IDENTIFICATION paragraph. |

| | |
|---|---|
| OPTIONS | Signifies that cards specifying modeling and input/output options follow. This paragraph may be omitted if default or previously specified values are to be used for all options. See Table I.3 for description of the option cards. |
| (insert cards) | |
| END | Terminates the OPTIONS paragraph. |
| DATA | Signifies beginning of the DATA paragraph which describes the emission sources and their receptors. |
| ORIGIN $X_o$,$Y_o$,E | Defines geodetic origin of the land area for which the MULTIMAX air dispersion modeling is being performed, $X_o$ and $Y_o$ are the X and Y Cartesian coordinates for the center of the area (or any convenient point in the area) and may be specified as Universal Transverse Mercator coordinates, kilometers (see Appendix IV). If $X_o$ and $Y_o$ are both input as 0.0, only a local reference point of (0.0) is used. The symbol E is the elevation of the stack bases' plane above mean sea level, with units of feet or meters being specified in the OPTIONS paragraph. The value of E will be subtracted from all receptor elevations input. If the default RECEPTORS plane option is selected, the value of E is immaterial. All emitting stacks (sources) are assumed to be situated on this single base plane.<br>FORMAT(A6,4X,3F10.0) |
| SOURCES | Indicates the beginning of the sources definitions paragraph. The parameters for each source are specified by means of 2 cards per source as shown in Table I.4. Currently, from 1 to 100 sources may be specified. |
| (insert cards) | |
| ENDEND | Terminates input of source definition cards. |

| | |
|---|---|
| RECEPTORS | Indicates the beginning of the receptors definitions paragraph. Table I.5 shows how the receptors may be specified. Up to 300 receptors may be specified.<br>Note that if the ADD RECEPTORS feature is being employed, only the additional receptors not alreay defined in the RESTART file are to be entered. Also, do not enter the IDENTIFICATION paragraph, ORIGIN card or SOURCES paragraph for this case. |
| (insert cards) | |
| END | Terminates DATA/RECEPTORS paragraph. |
| START | Starts Yearly Maxima computations. If, during these calculations, only 10 seconds of CAU time remain, the problem definition, status and all results to that point will be stored on the SAVE file. (About 1.2 seconds of CAU time are required for each receptor - source combination for a year's computations.) |
| RESTART | Restart the Yearly Maxima calculations, reading in the problem definition, status and previously obtained results from the RESTART unit (which was the SAVE unit from above). Only the RUN, ASG, USE, DO, FILES and STOP entries need be in the input deck. |
| PRINT RESULTS | Prints the Yearly Maxima results as obtained from the SAVE unit. The Source Contribution and All Receptor - Selected Times calculations will then be performed unless suppressed (see Options, Table I.3). This card need not be input after START and RESTART cards. Only the other entries noted under RESTART above need be made.<br>If the Yearly Maxima are on a SAVE file, it is only necessary to define the MET, SAVE and RESULTS files in the FILES paragraph followed by PRINT RESULTS and STOP cards, to generate the RESULTS file. |

| | |
|---|---|
| PRINT MET FILE | Causes the entire meteorological data file (unit MET in FILES paragraph) to be printed in compressed format. This requires about 70 pages for a year's data. This command also causes the statistical summary of the meteorological data to be printed. |
| PRINT MET STATISTICS ONLY | Causes only a statistical summary of the meteorological data file to be printed. This summary is very useful in comparing the data for several years. |
| SELECTED SOURCE CONTRIBUTIONS | Signifies that the following cards specify types of averages, receptor numbers and time periods for source contribution calculations. See Table I.6 for format of these specification cards. Only the other entries noted under RESTART need be made. The information is read from the SAVE file; a RESTART file should not be specified. |
| (insert cards) | |
| END | Terminates input of above specification cards. |
| ALL RECEPTORS - SELECTED TIMES | Signifies that the following cards specify types of averages and time periods for concentration calculations at all receptors. See Table I.6 for format of these cards (the receptor number input, if any, is ignored) 'ANNUAL' specification cards are also ignored. |
| (insert cards) | |
| END | Terminates input of above specification cards. |
| STOP | Stops the operation of Program MULTIMAX. |
| @FIN | Required by the Univac 1110 operating system to signify the end of the input deck. |

## TABLE I.2

## INPUT AND OUTPUT UNIT DESIGNATIONS FOR FILES PARAGRAPH

In the following, nn is the Logical Unit Number (LUN) corresponding to that on the @USE card for the file. It is to be entered anywhere within columns 11 to 20 with a trailing decimal point. The LUN name is to be entered with the first character in column 1.

| LUN Name | Value | Explanation |
|---|---|---|
| SAVE | nn. | Problem definition, status and Yearly Maxima results are always saved on this file. Also, if, during the Yearly Maxima calculations, insufficient CAU time remains to finish, the problem definition, status and results to that point will be saved on this file. |
| MET | nn. | Defines the LUN for the file containing hourly meterological data for the year (see Appendix III). |
| RESTART | nn. | Denotes the LUN to restart the yearly maxima computations from the place stored on a previous SAVE file. Although the SAVE and RESTART LUN's may be the same, it is recommended that different files be used in case of computer malfunction. |
| RESULTS | nn. | Define the LUN for output of Yearly Maxima and All Receptor - Selected Times results in formatted form that can be read by other programs. See Appendix VI for format descriptions. This card alone causes the output to be performed if the Yearly Maxima calculations have just been performed or if a PRINT RESULTS card is input to print a SAVE file. |

Note: The SAVE and MET files must always be designated. The RESTART and RESULTS files optionally depend upon the situations.

## TABLE I.3

## CARDS FOR OPTIONS PARAGRAPH

The following cards may be used to specify various computing and input/output options. The "designator phrase" is entered with the first character always in column 1. Several of the cards require numerical input in additional fields; these are defined in the "Explanation" column of the Table. The Default conditions applies if the card(s) is not input.

| Designator Phrase | Default | Explanation |
|---|---|---|
| ADD RECEPTORS | ------- | Add receptors to the problem as defined in the RESTART file (which was a previous SAVE file). In the DATA paragraph to follow, enter only the RECEPTORS, et. seq., cards for the receptors to be added. Model computing options, *per se* are not allowed to be changed. |
| WIND SPEED ADJUST | Yes | This allows one to change the height of the "ground level" wind speed observational height from the default value of 7.0 meters to the value punched into columns 21-30 of the card. Always enter the value with a decimal point. The wind speed adjustment uses a power law formula to "correct" the wind speed used in the modeling computations from the "ground level" to the physical stack height. |
| NO WIND SPEED ADJUST | Do It | Suppress the wind speed adjustment calculation in the modeling (see above). |
| ELEVATION METERS | Feet | The values for the elevations input on the ORIGIN and RECEPTORS cards are in meters. |
| ELEVATION FEET | Feet | Specifies that the values for the elevations input on the ORIGIN and RECEPTORS cards are in feet units. |
| RECEPTORS AS INPUT | Receptors on plane | Receptor heights are used exactly as input; i.e., $Z = Z_{in}$. |

| | | |
|---|---|---|
| RECEPTORS MOD1 | Receptors on plane | Let $Z_{in}$ = receptor elevation minus the stack base plane elevation input. Then $Z_{mod} = Z_{in}/2$. $Z_{mod}$, the receptor heights used in the modeling computations, is then limited to be equal to or less than the physical stack height minus 10 meters. |
| RECEPTORS MOD2 | Receptors on plane | Same as MOD1 but $Z_{mod}$ limited to be less than or equal to the effective plume height minus 10 meters. |
| TALL STACK APPROXIMATION | Classical Plume Equation | Use the "tall stack" approximation to the Classical Gaussian Plume model (see main text, page 25). |
| URBAN MIXING HEIGHTS | Rural Mixing Heights | Use the urban mixing height data from the MET file instead of the rural ones. |
| DO SAMPLE TIME CORRECTION | Not done | Suppress the power law correction of the concentration from the 10 minute to the 1 hour sampling time basis. |
| CALIBRATE | Not done | Apply the "calibration" equation<br>$\chi_{out} = A\chi_{mod} + B$<br>where $\chi_{mod}$ is the original concentration output from the modeling calculations (with or without sampling time corrections), A is the value input in columns 11-20 of this card and B is the value entered into columns 21-30. Always punch a decimal point with the value. |
| NO SOURCE CONTRIBUTIONS | Done | Do not perform the Source Contribution calculations after the Yearly Maxima computations or on input of a PRINT RESULTS card. |
| NO SELECTED TIME PERIODS - ALL RECEPTORS | Done | Do not perform the All Receptors - Selected Times calculations after the Yearly Maxima computations or on input of a PRINT RESULTS card. |
| HIGH PRINT nn. | Print all receptors | Print only the nn highest receptors for each type of concentration average. Input nn. with decimal in columns 11-20. |

| | | |
|---|---|---|
| NO RECEPTOR PRINT | Do print | Suppress receptor description print on output. |
| NO MET DATA PRINT | Do print | Suppress meteorological data print for highest average concentration days. |
| FORCE RECEPTOR PRINT | Not done | Print complete list of receptors. Receptor descriptions normally print only immediately after input - not with 'PRINT RESULTS', 'RESTART', etc. commands. |
| NO STABILITY CLASS LIMIT | Limit used | The hourly sequence of stability classes for a given day is used as read from the MET data file. If this card is not input, the stability class value will not be allowed to change by more than ± from one hour to the next. (CRSTER employs this device; its use may be questioned.) |

## TABLE I.4

## CARDS FOR DEFINITION OF SOURCE PARAMETERS

Each emitting source is defined by a pair of cards. The first card of the pair contains the source's location and may optionally define it as a flare stack. This card may define the source location in either "polar" or Cartesian coordinates. If polar, the origin is that on the ORIGIN card and the azimuth angle is taken in degrees clockwise from North. If Cartesian coordinates are used, they may refer to the local origin (ORIGIN card) or be directly input in Universal Transvere Mercator (UTM) coordinates. The second card of the pair contains emission parameters for the stack (columns 1-20 may contain anything for additional identification but is disregarded by the program).

| Card 1 | | Card 1 | Field Contents for: | |
|---|---|---|---|---|
| Field | Format | Columns | POLAR Case | CARTesian Case |
| 1 | 3A6,2X | 1 - 18 | Source description | Source description |
| 2 | A1,4X | 21 - 25 | 'POLAR' or 'P' | 'CARD' or 'C' or blank |
| 3 | A1,4X | 26 - 30 | (not used) | 'LOCAL' or 'UTM' (see note) |
| 4 | F10.0 | 31 - 40 | Radius length to source point, km | X-coordinate value for point, km. |
| 5. | F10.0 | 41 - 50 | Azimuth value for point, degrees | Y-coordinate value for point, km. |
| 6 | A5,5X | 51 - 55 | 'FLARE' if it is a flare or burning stack; otherwise leave field blank. | Same as for the POLAR case. |
| 7 | F10.0 | 61 - 70 | Heating rate if field 6 is 'FLARE' kcal/sec. Otherwise leave blank. | Same as for the POLAR case. |

Note: The computer only "looks at" the first letter, so 'L' or 'U' may be used for 'LOCAL' or 'UTM', respectively. Also, if this field is left blank, the default condition is that of the ORIGIN card. That is, if the coordinates of the origin are given as (0.0,0.0 (or blanks)) on the ORIGIN card, it is assumed here that the coordinates refer to the origin. If nonzero coordinates are given on the ORIGIN card, then it is assumed here that the coordinates are in the Universal Transverse Mercator system.

Second Card of a Source Definition Pair:

| Card 2<br>Field | Format | Card 2<br>Columns | Contents |
|---|---|---|---|
| 1 | 20X | 1 - 20 | Anything (not used by program) |
| 2 | F10.0 | 21 - 30 | Stack height, meters |
| 3 | F10.0 | 31 - 40 | Stack diameter, meters |
| 4 | F10.0 | 41 - 50 | Stack gas exit velocity, meters/second |
| 5 | F10.0 | 51 - 60 | Stack gas temperature, degrees Kelvin |
| 6 | F10.0 | 61 - 70 | Pollutant emission rate, grams/second |

## TABLE I.5

## CARDS FOR SPECIFICATION OF RECEPTOR LOCATIONS AND ELEVATIONS

Three main types of receptor specification cards may be input: POINT, LINE and CIRCLE; their ordering does not matter. If nonzero receptor heights are to be used (the RECEPTORS are not on the stack base plane), then only the POINT type of cards are allowed. As with the SOURCES cards, for each of these types the location may be specified in either "polar" or Cartesian coordinates, with the polar angle as degrees clockwise from North. If Cartesian coordinates are used, they may refer to the local origins as defined on the ORIGIN card or be input directly in Universal Transverse Mercator (UTM) coordinates.

POINT Receptor definition cards:

| | | | Field Contents for: | |
|---|---|---|---|---|
| Field | Format | Columns | POLAR Case | CARTesian Case |
| 1 | A5,5X | 1 - 5 | 'POINT' | 'POINT' |
| 2 | Al,4X | 11 - 15 | 'POLAR' or 'P' | 'CART' or 'C' or blank |
| 3 | Al,4X | 16 - 20 | Not used (coordinates always refer to the local origin) | 'LOCAL' or 'UTM' (The note for Table I.4, page 67, also applies here) |
| 5 | F10.0 | 21 - 30 | Radius value, km | X-coordinate, km |
| 6 | F10.0 | 31 - 40 | Azimuth angle, deg. | Y-coordinate, km |
| 7 | F10.0 | 41 - 50 | Elevation (see note) | Elevation (see note) |

Note: Elevation is above mean sea level, see OPTIONS for units-of-measure. See also description of ORIGIN card, page 60.

CIRCLE Receptor definition cards:

| | | | Field Contents for: | |
|---|---|---|---|---|
| **Field** | **Format** | **Columns** | **POLAR Case** | **CARTesian Case** |
| 1 | A6,4X | 1 - 6 | 'CIRCLE' | 'CIRCLE' |
| 2 | A1,4X | 11 - 15 | 'POLAR' or 'P' | 'CART' or 'C' or blank |
| 3 | A1,4X | 16 - 20 | Not used (coordinates always refer to the local origin) | 'LOCAL' or 'UTM' (The note for Table I.4, page 67 also applies) |
| 4 | F10.0 | 21 - 30 | Radius to location of circle center, km | X-coordinate for center of circle, km |
| 5 | F10.0 | 31 - 40 | Azimuth angle for circle center, deg. | Y-coordinate for center of circle, km |
| 5 | F10.0 | 41 - 50 | Radius of Circle, km | Radius of Circle, km |
| 6 | F10.0 | 51 - 60 | Number of points on circle or arc | Number of points on circle or arc |
| | | | (always punch with decimal point) | |
| 7 | F10.0 | 61 - 70 | Degrees for first receptor point on the circle or arc | Degrees for first receptor point on the circle or arc |
| 8 | F10.0 | 71 - 80 | Degrees between each receptor point | Degrees between each receptor point |
| | | | (operating clockwise, arc may pass through 360 degrees) | |

LINE Receptor definition cards:

| Field | Format | Columns | POLAR Case | CARTesian Case |
|---|---|---|---|---|
| 1 | A4,6X | 1 - 4 | 'LINE' | 'LINE' |
| 2 | A1,4X | 11 - 15 | 'POLAR' or 'P' | 'CART' or 'C' or blank |
| 3 | A1,4X | 16 - 20 | Not used (coordinates always refer to the local origin) | 'LOCAL' or 'UTM' (The note for Table I.4, page 67 also applies) |
| 4 | F10.0 | 21 - 30 | Radius to starting receptor point on the line, km | X-coordinate for the starting receptor point on the line, km |
| 5 | F10.0 | 31 - 40 | Radius to last receptor point on the line, km | X-coordinate for the last receptor point on the line, km |
| 7 | F10.0 | 51 - 60 | Azimuth angle for last receptor point on line, deg. | Y-coordinate for the last receptor point on the line, km |
| 8 | F10.0 | 61 - 70 | Number of receptor points on the line | Number of receptor points on the line |

(always punch with decimal point)

## TABLE I.6

## AVERAGE TYPE - RECEPTOR - TIME PERIOD SPECIFICATION CARDS FOR 'SELECTED SOURCE CONTRIBUTIONS' OR 'ALL RECEPTORS - SELECTED TIMES'

| Field | Format | Columns | CONTENTS |
|---|---|---|---|
| 1 | A6,4X | 1 - 6 | 'ANNUAL' or 'DAY' or '3-HOUR' or '1-HOUR' according to the respective type of concentration average to be calculated. ('DAY' refers to the 24-hour average) |
| 2 | F10.0 | 11 - 20 | Receptor No. |
| 3 | F10.0 | 21 - 30 | Day No. (not applicable for ANNUAL average) |
| 4 | F10.0 | 31 - 40 | Hour No. (not applicable for ANNUAL or DAY type averages) |

Notes:
1. The numbers for fields 2-4 are always punched with the trailing decimal point.
2. Receptor No. is ignored by the program for the ALL RECEPTORS - SELECTED TIMES paragraph. However, input some nonzero number or else the program will crash.
3. The hour number for the 3-HOUR averages refers to the first hour of the triad.
4. For SELECTED SOURCE CONTRIBUTIONS, a maximum of 57 specification cards may be input.
5. For ALL RECEPTORS - SELECTED TIMES, a maximum of 19 specification cards may be input.

# APPENDIX II

## IBM 360/370 USER'S GUIDE FOR PROGRAM MULTIMAX

## FOREWORD TO APPENDIX II

Following is the write-up for the use of the IBM-compatible version of MULTIMAX as provided by Mr. Condrey of the TVA; no changes have been made. It is suggested that Appendix I be read and used as the more completely descriptive text. The following, however, provides a complete check-list of what is allowed or required for input to the IBM version of MULTIMAX.

The main features not allowed in the IBM-compatible version (compared with the UNIVAC version) are the use of SAVE, RESTART and RESULTS files and the ability to just ADD RECEPTORS to the results of a previous run.

Apendix VII briefly discusses some machine-dependent features of the computer program.

A complete example of the input run stream and the concomitant results is presented in Appendix X.

NAME: MULTIMAX

### DIVISION AND BRANCH (OF TENNESSEE VALLEY AUTHORITY)

Division of Natural Resources Services, Air Quality Branch

### RESPONSIBLE PROGRAMMER

Jerry W. Condrey, River Oaks Building, Muscle Shoals, Alabama 35660

### General Information

The MULTIMAX dispersion model was developed by the Shell Oil Company and bought by TVA. TVA received the model in late September 1978, in the UNIVAC FORTRAN. The program has been converted to run on TVA's IBM computing system.

The UNIVAC version contained statements whose function was to save the problem definition and results to date for restarting of the program if it could not completely execute in the time allowed on Shell's computer. The IBM version does not allow for saving the status or restarting since TVA's IBM system does not permit the extensive communication between program and system permitted at Shell. Some options specified in the manual provided with MULTIMAX are associated with restarting so are not available (but should not be needed) with the IBM version. Available options can be noted under Card Input for MULTIMAX.

### File Information

Most files associated with the UNIVAC version of MULTIMAX have been eliminated. Necessary files are:

FT09F001 - A year of meteorological data compatible with EPA's CRSTER model. The file should be unformatted, with DCB=(LRECL=688,RECFM=VBS, BLKSIZE=4132) except other blocksizes may be acceptable as long as they are compatible with the logical record length.

FT06F001 - A standard printer file.

FT05F001 - Card input file.

For card input, note that options and other input are often specified in plain English. Information in quotes should be entered exactly as indicated, without the quotes. Note that such input is associated with a format of (A) without a length specification. In these instances, the length will not be of concern to the user as long as data is entered into the correct columns.

## Additional Requirements

MULTIMAX runs in 300K bytes of Core. CPU time is a function of the number of sources and number of receptors being considered and the options specified. Also, CPU time will vary greatly from computer to computer. On the IBM 370/65 computer, about 200 CPU seconds were required to run 17 sources and 15 receptors when TALL STACK APPROXIMATION, FINAL PLUME RISE, and PRINT MET STATISTICS were the options specified. The run was for 366 days.

NOTE: The MULTIMAX model was developed by J. H. Moser of the Chemical Engineering Department, Shell Development Company, a division of Shell Oil Company.

## Card Input for MULTIMAX

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| 1 | 1-14 | 'IDENTIFICATION'<br>Begins identification paragraph. Indicates that identification information follows. | (A) |
| 2 | 1-80 | Identification information to be printed. Card 2 may be repeated up to 20 times. The first will be used for printing the problem description heading. | (A) |
| 3 | 1-3 | 'END'<br>Ends identification paragraph. | (A) |
| 4 | 1-7 | 'OPTIONS'<br>Begins options paragraph. Indicates that options will follow. The options paragraph (cards 4-25) may be omitted if only defaults are to be used. Option cards (5-24) may be supplied in any order. | (A) |
| 5 | 1-9 | 'CALIBRATE'<br>Apply the calibration formula $\chi_{out} = A\chi_{mod} + B$ where $\chi_{mod}$ is the modeling calculations, $\chi_{out}$ the concentrations to be output, and A and B the coefficients explained below. If the option is not specified, no adjustment will be made to $\chi_{mod}$ for output. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 11-20 | The slope (A) in the calibration equation. | (F10.0) |
| | 21-30 | The background or Y intercept (B) in the calibration equation. | (F10.0) |
| 6 | 1-10 | 'HIGH PRINT'<br>Print concentration information of each type only for as many highest receptors as indicated. If not specified, highest concentrations at each receptor will be printed. | (A) |
| | 11-20 | The number of highest receptors at which concentrations should be printed. | (F10.0) |
| 7 | 1-9 | 'NO ANNUAL'<br>Suppress annual average calculations. By default, they are done. | (A) |
| 8 | 1-9 | 'NO 3 HOUR'<br>Suppress 3-hour average calculations. By default, they are done. | (A) |
| 9 | 1-23 | 'NO SOURCE CONTRIBUTIONS'<br>Do not perform the source contribution calculations after the yearly maxima computations. By default, this is done (if there is more than one source). | (A) |
| 10 | 1-17 | 'WIND SPEED ADJUST'<br>Assume the meteorological input data was recorded at the indicated level rather | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | than the 7-meter default. Wind speed data will be extrapolated by a power law formula based on stability class whether this card is included or not, unless card 11 is included, so the only purpose for including it should be to change the data recording level. | |
| | 21-30 | Height of measured wind speed in meters. | (F10.0) |
| 11 | 1-20 | 'NO WIND SPEED ADJUST'<br>Don't extrapolate wind speed. (Assume wind speed the same at all levels). | (A) |
| 12 | 1-25 | 'DO SAMPLE TIME CORRECTION'<br>Use the power law correction from the 10 minute to the 1 hour sampling time basis. By default, this is not done. | (A) |
| 13 | 1-20 | 'URBAN MIXING HEIGHTS'<br>Use the urban mixing height data from the meteorological data file. By default, the rural mixing heights are used. | (A) |
| 14 | 1-18 | 'RECEPTORS AS INPUT'<br>Receptor heights used exactly as input. By default, receptors will be on a plane. | (A) |
| 15 | 1-14 | 'RECEPTORS MOD1'<br>Let $Z_{in}$ = receptor elevation input minus the stack base plane elevation input. Then $Z_{mod} = Z_{in}/2$ and is limited to be less than | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | or equal to the physical stack height minus 10 meters ($Z_{mod}$ will be the elevation actually used in the modeling computations).<br>Same default as for card 14. | |
| 16 | 1-14 | 'RECEPTORS MOD2'<br>Same as for MOD1 except $Z_{mod}$ will be limited to be less than or equal to the effective plume height minus 10 meters.<br>Same default as for card 14. | (A) |
| 17 | 1-24 | 'TALL STACK APPROXIMATION'<br>Use the tall stack approximation to the Classical Gaussian Plume model. By default, the Classical Plume Equation will be used. | (A) |
| 18 | 1-17 | 'NO RECEPTOR PRINT'<br>Suppress print of receptor descriptions.<br>By default, these descriptions are printed. | (A) |
| 19 | 1-17 | 'NO MET DATA PRINT'<br>Suppress meteorological data print for highest average concentration days. This data is printed by default. | (A) |
| 20 | 1-16 | 'ELEVATION METERS'<br>Indicates that the elevations input on ORIGIN and RECEPTORS cards are in meters.<br>By default, these elevations are assumed to be in feet. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| 21 | 1-14 | 'ELEVATION FEET'<br>Indicates that the elevations input on the ORIGIN and RECEPTORS cards are in feet. This is the default so this card is never really necessary. | (A) |
| 22 | 1-39 | 'NO SELECTED TIME PERIODS--ALL RECEPTORS'<br>Do not perform the all receptors--selected times calculations after the yearly maxima computations. By default, this is done. | (A) |
| 23 | 1-24 | 'NO STABILITY CLASS LIMIT'<br>Stability class will be used as read from the meteorological data file. By default, stability class will not be permitted to vary by more than one class per hour. | (A) |
| 24 | 1-16 | 'FINAL PLUME RISE'<br>Use final plume rise. By default, trajectory plume rise will be used. | (A) |
| 25 | 1-3 | 'END'<br>Ends options paragraph | (A) |
| 26 | 1-4 | 'DATA'<br>Begins data paragraph. Indicates that source and receptor information follows. | (A) |
| 27 | 1-6 | 'ORIGIN'<br>The geodetic origin of the land area for which the modeling will be performed is being specified. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 11-20 | X cartesian coordinate of geodetic origin (in kilometers). | (F10.0) |
| | 21-30 | Y cartesian coordinate of geodetic origin ( in kilometers). | (F10.0) |
| | 31-40 | The elevation of the stack base plane above mean sea level (in meters or feet, depending on option--see cards 20-21). If both X and Y are input as 0, only a local reference point of 0 is used. The elevation is ignored unless either card 14, 15, or 16 is included. | (F10.0) |
| 28 | 1-7 | 'SOURCES'<br>Source information follows. From 1 to 100 sources may be specified. 2 cards (29-30) per source. | (A) |
| 29 | 1-12 | Source Description | (A) |
| | 21-25 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |
| | 26-30 | Blank for polar case. 'LOCAL' or 'UTM' for cartesian. If left blank for cartesian the ORIGIN card will be looked at and if X and Y were both input as 0.0, 'LOCAL' is assumed--otherwise 'UTM' (universal Transverse Mercator System) is assumed. Left justify. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 31-40 | Radius length to point if polar--X coordinate for point if cartesian. Always in kilometers. | (F10.0) |
| | 41-50 | Azimuth value for point in degrees if polar--y coordinate for point in kilometers if cartesian. | (F10.0) |
| | 51-55 | 'FLARE' if a flare or burning stack--otherwise blank. | (A) |
| | 61-70 | Heating rate in kcal/sec for flare stack--otherwise blank. | (F10.0) |
| 30 | 21-30 | Stack height (meters) | (F10.0) |
| | 31-40 | Stack diameter (meters) | (F10.0) |
| | 41-50 | Stack gas exit velocity (m/sec) | (F10.0) |
| | 51-60 | Stack gas temperature ($^{o}$K) | (F10.0) |
| | 61-70 | Pollutant emission rate (gm/sec) | (F10.0) |

Repeat cards 29 and 30 for all sources.

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| 31 | 1-6 | 'ENDEND'<br>Ends input of sources. | (A) |
| 32 | 1-9 | 'RECEPTORS'<br>Receptor information follows. From 1 to 300 receptors may be specified. 3 types of cards may be used to define the receptors and may appear in any order. Only POINT cards (card 33) may be used for nonzero receptor heights. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | CIRCLE cards (card 34) and LINE cards (card 35) may be used as well as POINT cards to define receptors on a plane. | |
| 33 | 1-5 | 'POINT' | (A) |
| | 11-15 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |
| | 16-20 | Blank for polar cases. 'LOCAL' or 'UTM' for cartesian. See card 29, column 26-30 for default rules. Left justify. | (A) |
| | 21-30 | Radius length to receptor point if polar--X coordinate for point if cartesian. Always in kilometers. | (F10.0) |
| | 31-40 | Azimuth value for point in degrees if polar--Y coordinate for point in kilometers if cartesian. | (F10.0) |
| | 41-50 | Elevation of receptor above mean sea level (in feet or meters depending on option--see cards 20-21). Also, note the relation to the elevation specified on the ORIGIN card (card 27). | (F10.0) |
| 34 | 1-6 | 'CIRCLE' | (A) |
| | 11-15 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 16-20 | Blank for polar cases. 'LOCAL' or 'UTM' for cartesian. See card 29, column 26-30 for default rules. Left justify | (A) |
| | 21-30 | Radius length to center of circle if polar--X coordinate for center of circle if cartesian. Always in kilometers. | (F10.2) |
| | 31-40 | Azimuth value for center of circle in degrees if polar--Y coordinate for center of circle in kilometers if cartesian. | (F10.2) |
| | 41-50 | Radius of circle in kilometers. | (F10.2) |
| | 51-60 | Number of points on circle or arc. | (F10.2) |
| | 61-70 | Degrees for first receptor point on circle or arc. | (F10.2) |
| | 71-80 | Degrees between each receptor point on circle or arc.<br>Note: This card defines the number of receptors indicated in columns 51-60. This number, not one, is charged against the 300 maximum. | (F10.2) |
| 35 | 1-4 | 'LINE' | (A) |
| | 11-15 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |
| | 16-20 | Blank for polar cases. 'LOCAL' or 'UTM' for cartesian. See card 29, column 26-30 for default rules. Left justify. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 21-30 | Radius length to starting receptor point on the line if polar--X coordinate for this point if cartesian. Always in kilometers. | (F10.2) |
| | 31-40 | Azimuth value for starting receptor point on the line in degrees if polar--Y coordinate for this point in kilometers if cartesian. | (F10.2) |
| | 41-50 | Radius length to last receptor point on the line if polar--X coordinate for this point if cartesian. Always in kilometers. | (F10.2) |
| | 51-60 | Azimuth value for last receptor point on the line in degrees if polar--Y coordinate for this point in kilometers if cartesian. | (F10.2) |
| | 61-70 | Number of receptor points on the line.<br>Note: This card defines the number of receptors indicated in columns 61-70. This number, not one, is charged against the 300 maximum. | (F10.2) |
| 36 | 1-3 | 'END'<br>Ends DATA paragraph. | (A) |
| 37 | 1-5 | 'START'<br>Calculate concentrations for the full year at all receptors considering all sources. | (A) |
| 38 | 1-29 | 'ALL RECEPTORS--SELECTED TIMES'<br>Indicates that the cards which follow specify types of averages and time periods for concentration calculations at all receptors. This feature is optional and cards 38-40 should be omitted if it is not being used. If desired, | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | it may be used independently of the yearly maxima calculations. | |
| 39 | 1-6 | Type of average: 'ANNUAL', 'DAY', '3-HOUR', or '1-HOUR'. Left justify. | (A) |
| | 21-30 | Day number. Does not apply to annual averages. | (F10.0) |
| | 31-40 | Hour number. Does not apply to annual or daily averages. For 3-hour averages, refers to the first hour of the triad.<br>Card 39 may be repeated up to 19 times. | (F10.0) |
| 40 | 1-3 | 'END'<br>Ends input of specification cards for all receptors--selected times. | (A) |
| 41 | 1-29 | 'SELECTED SOURCE CONTRIBUTIONS'<br>Indicates that the cards which follow specify types of averages, receptor numbers, and time periods for source contribution calculations. This feature is optional and cards 41-43 should be omitted if it is not being used. If desired, it may be used independently of the yearly maxima calculations. | (A) |
| 42 | 1-6 | Type of average: 'ANNUAL', 'DAY', '3-HOUR', or '1-HOUR'. Left justify. | (A) |
| | 11-20 | Receptor number. | (F10.0) |
| | 21-30 | Day number. Does not apply to annual averages. | (F10.0) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 31-40 | Hour number. Does not apply to annual or daily averages. For 3-hour averages, refers to the first hour of the triad. | (F10.0) |
| | | Card 42 may be repeated up to 57 times. | |
| 43 | 1-3 | 'END'<br>Ends input of specification cards for selected source contributions. | (A) |
| 44 | 1-14 | 'PRINT MET FILE'<br>Print meteorological data file plus statistical information on the data in the file. Omit this card if such output is not desired. | (A) |
| 45 | 1-25 | 'PRINT MET STATISTICS ONLY'<br>Output only statistical information on the meteorological data--not the data itself. Omit this card if such output is not desired. | (A) |
| 46 | 1-4 | 'STOP'<br>Terminates run of MULTIMAX. | (A) |

# APPENDIX III

## HINTS ON USING PROGRAM MULTIMAX

Shell users may access the Univac 1110 computer via the Batch Link Interface (BLI) from the IBM 370 timesharing computer which uses the CMS software. Therefore, MULTIMAX was designed so that it can be completely "operated" from a telephone-connected terminal of 80 character linewidth. Thus the input "card deck" for the program may be a real deck of cards input via a remote batch terminal to the Univac 1110 or it may be a CMS file of card images. With CMS, the input data file may be easily constructed (see Appendix I for formats) by means of the CMS Editor.

Since the Yearly Maxima computations require a fairly large amount of computer time if a number of sources are involved (about 1.2 seconds of CAU time per source-receptor pair), the receptors should be located judiciously to minimize the total computing cost. It is suggested that four or five concentric circles covering the area be first used, with about 20 to 30 degrees separation between the points. Run the program and it will generally be found that all the germane concentration maxima lie within a particular sector of the compass rose because of prevailing winds for the area. Then, to better define the location and concentration magnitudes of the various maxima, add arcs of receptors between the already calculated ones, both on the loci of previously used circles and between these circles. Note that a separation of less than ten degrees need not be used because the original wind directions were only recorded to the nearest ten degrees by the Weather Service. Also, if some of the terrain contains significant elevations above the stack base plane, place some receptors on or near these features.

To check-out the input data deck with minimum man-time and cost, prepare the initial input deck with the very highest run priority and omit the START card following the DATA paragraph. This usage will cause MULTIMAX to generate diagnostic messages of input data errors, if any, and with essentially immediate turnaround time. This part of the program operates extremely fast, so the additional cost of using the highest priority will not be significant. MULTIMAX always prints the card images read-in, then if numerical values are involved, prints-out the values with numerical formats. These should be examined carefully for decimal point errors, etc.

When all the errors have been corrected in the input deck, change the priority on the run card to a lower cost prime-time one and the maximum run time to a few minutes. Add the START card and input the deck. This may generate additional diagnostics not previously ascertainable from the input data deck alone. If all is well, prepare an input deck with a priority and allowable run time sufficient to complete the calculations and containing only the @-control cards, the FILES paragraph, the RESTART and the STOP cards. This deck may also be immediately checked for "keypunch" errors by using the highest run priority but leaving out the RESTART card.

One should always use different RESTART and SAVE files in case unforseeable computational difficulties arise. This will prevent the loss of results-to-date and allow the use of the restart option[11] on the run card. The latter allows the computer operator to resubmit the input data if the computer crashes during an overnight run.

If CMS is being used, it is assumed here that the user can obtain local assistance in learning the few simple commands necessary for use of the Batch Link Interface. However, many CMS users are not familiar with the column selection option of the CMS' TYPE command. To type out selected columns of a file, type-in

```
TYPE fn ft (COL n1 n2
```

where fn is the filename, ft is the filetype, $n_1$ is the starting column number and $n_2$ is the final column number. Thus to type the meaningful information returned from the Univac 1110 in a 132 character wide output file, use:

```
TYPE fn ft (COL 2 81
```

After the modeling studies for a particular project have been completed, it is advisable to store the appropriate SAVE files on Univac 1110 magnetic tapes. Otherwise, if computer reference is not made to a file for two weeks, it will be removed from disk storage. After 6 months, it will be irretrievably lost. If the SAVE files are stored on tape, one may use the PRINT RESULTS command for additional listings, etc. that may be needed later for reports, etc.

## APPENDIX IV

## METEOROLOGICAL DATA INFORMATION

The original Univac version of MULTIMAX was developed to read the formatted meteorological data as input to the MAXT24 (CRSTER) version and prepared by the then-existent "preprocessor" for the "raw" data. The Univac version of MULTIMAX still uses the formatted data file with the addition of one record (80 characters) of descriptive information preceding the data records. Since that time, the EPA has distributed a new, Fortran version of the preprocessor program in conjunction with the latest version of CRSTER on the EPA's UNAMAP magnetic tape. The latest version of the preprocessor and CRSTER produce/use an unformatted (binary) meteorological data file. The IBM-compatible version of MULTIMAX uses the latter unformatted file in which the first four INTEGER*4 words relate the weather station information rather than the 80-character identification record used in the Univac version. Thus to convert the meteorological data file from one form to the other, one could write a short computer program which recognizes these differences. For reference purposes, reading of the meteorological data file is performed in subroutines COMPUT, ALLPER, ALLMET AND SCAN.

Thus, the CRSTER preprocessor program[13] may be used to process the "raw" meteorological data to be used for input to MULTIMAX. Also a number of consulting environmental firms provide the service of obtaining the raw data from the National Weather Service and converting to the form(s) required by CRSTER and MULTIMAX.

"RAW" meteorological data is available from:

The National Climatic Center
National Oceanic and Atmospheric Administration
Federal Building
Asheville, North Caroline 28801

To find out what data is available for a particular geographical location, or to make direct arrangements for obtaining the data, telephone Mr. Vincent Hagarty of the above organization at 704-258-2850, extension 0203. Mr. Hagarty is very cordial and helpful.

Although representative surface observation data is generally available for an area on a hourly basis, most mixing height data is available only a twice-daily basis. Therefore, certain hourly observed variables must be used to find the Pasquill atmospheric stability class and the mixing height data interpolated to an hourly basis and the results combined into the form required for input to MULTIMAX. The algorithm recommended by the EPA for finding the stability classes is given in Reference 12. The algorithm for interpolating the mixing layer heights, as obtained from the EPA and used in the CRSTER preprocessor follows.

## MIXING LAYER HEIGHT INTERPOLATION ALGORITHM

Two types of mixing heights are calculated, one is for basically rural surroundings, and the other is for urban locations. The user is given the option to specify which he wants to use. The way in which hourly mixing height are determined from maximum mixing heights (MXDP) for yesterday (i-1), today (i) and tomorrow (i+1) and mimimum mixing height (MNDP) for today (i) and tomorrow (i+1) is depicted in Figure 1.

For urban mixing height, between midnight and sunrise; if the stability is neutral interpolate between $MXDP_{i-1}$ and $MXDP_i$ ①, if stability is stable use $MNDP_i$ ②. For hours between sunrise and 1400, if the hour before sunrise was neutral, interpolate between $MXDP_{i-1}$ and $MXDP_i$ ③. For sunrise to 1400, if the hour before sunrise was stable, interpolate between $MNDP_i$ and $MXDP_i$ ④. For 1400 to sunset, use $MXDP_i$ ⑤. For hours between sunset and midnight; if stability is neutral interpolate between $MXDP_i$ and $MNDP_{i+1}$ ⑥, if stability is stable interpolate between $MSDP_i$ and $MNDP_{i+1}$ ⑦.

For rural mixing height between midnight and sunrise, interpolate between $MXDP_{i-1}$ and $MXDP_i$ ⑧. For hours between sunrise and 1400, if the hour before sunrise was neutral interpolate between $MXDP_{i-1}$ and $MXDP_i$ ⑨. For sunrise to 1400, if the hour before sunrise was stable, interpolate between 0 and $MXDP_i$ ⑩. For 1400 to sunset, use $MXDP_i$ ⑪. For sunset to midnight, interpolate between $MXDP_i$ and $MXDP_{i+1}$ ⑫.

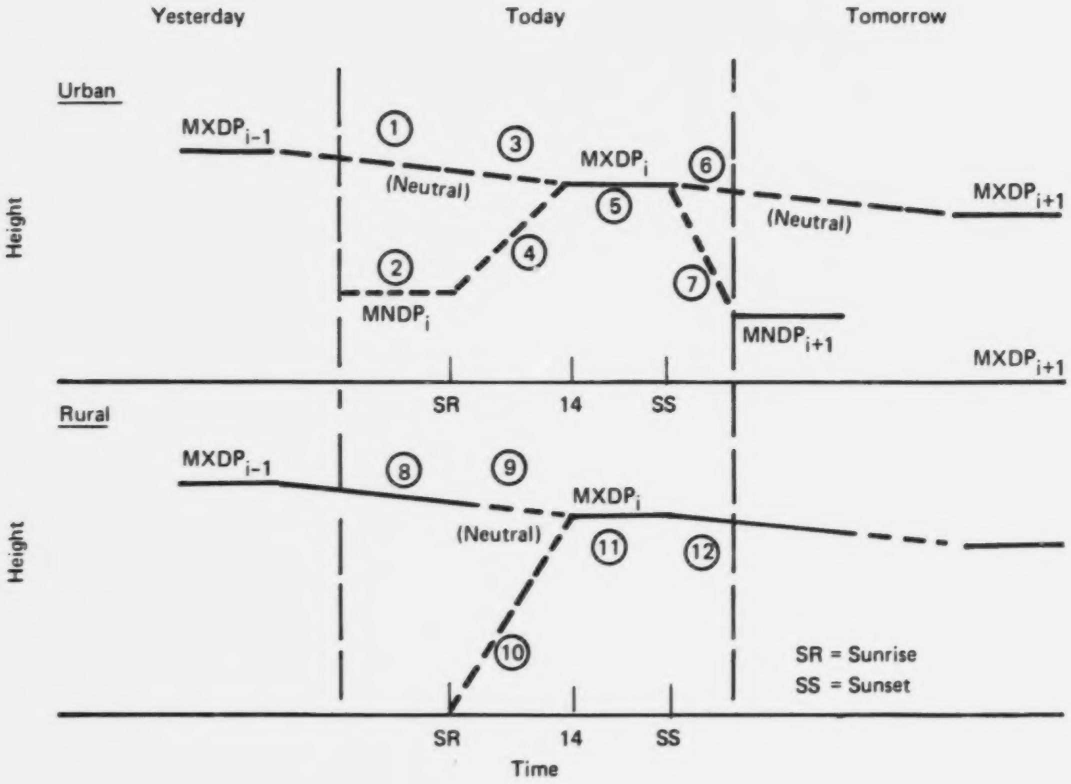
Yesterday
Today
Tomorrow
Urban
Height
MXDP$_{i-1}$
①
③
MXDP$_i$
⑥
(Neutral)
⑤
(Neutral)
MXDP$_{i+1}$
④
②
⑦
MNDP$_i$
MNDP$_{i+1}$
MXDP$_{i+1}$
SR
14
SS
Rural
Height
MXDP$_{i-1}$
⑧
⑨
MXDP$_i$
(Neutral)
⑪
⑫
⑩
SR = Sunrise
SS = Sunset
SR
14
SS
Time

**Figure IV. Determination of Mixing Heights**

01352

## APPENDIX V

## TOPOGRAPHICAL MAP INFORMATION

### Maps

It is recommended that United States Department of Interior Geological Survey "7-1/2 Minute" series topographical maps be used in laying-out receptor locations and elevations for air dispersion modeling studies. These maps have a scale reduction of 1:24000, that is 1 inch represents 2000 feet. At least 4 of these maps may be required for an area containing a 10 kilometer radius circle. The "15 Minute" series may be used, especially for flat terrain, but the contour lines are very difficult to read with accuracy so elevations may contain appreciable error. The 15 Minute series are scaled 1:62500 and 1 inch represents nearly a mile. Information and maps may be obtained from the following sources:

U. S. Geological Survey
National Map Information Office
12201 Sunrise Valley Drive
Reston, Virginia 22092
Telephone: 703-860-6045

U. S. Geological Survey
Eastern Region - Map Distribution
1200 South Eads Street
Arlington, Virginia 22202
(Telephone number not known)

U. S. Geological Survey
Denver Distribution Center
Federal Center - Building 41
Box 25286
Denver, Colorado 80225
Telephone: 303-234-3832

### Universal Tranverse Mercator Coordinate System

The above mentioned maps generally have blue tick marks on their borders showing the Universal Transverse Mercator (UTM) coordinates. These are shown at 1 kilometer intervals for the 7-1/2 Minute series.

## APPENDIX VI

## 'RESULTS' OUTPUT FILE FORMATS

If a nonzero RESULTS unit is specified in the FILES paragraph input to program MULTIMAX, the Yearly Maxima and All Receptors - Selected Times results will be written to that file in formatted form; this file may then be read by other programs for plotting, statistical analysis, etc. for simplicity, a listing of an example RESULTS file has been annotated to show the various germane formats. Slash marks (/) shown in bold on the listing show that the blank records were output by slashes in the format statement; the Univac will read all such lines as one record.

The listing shows formats only; the numerical results do not correspond to the example input deck of Appendix I.

(Listing follows)

```
    MULTIMAX EXAMPLE CASE 1                                                                          DATE 030377
@DATA,L  RESULTS.
DATA008-ML1C08-2-4 03/03-08:34:11
000001       1MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
000002                                         RUN STARTED:   3 MAR 1977       0120132
000003       @PROBLEM TITLE:
000004
000005        EXAMPLE CASE FOR TESTING OF PROGRAM MULTIMAX.
000006        THIS CASE IS FOR TWO SOURCES AND A SMALL NUMBER OF RECEPTORS.
000007       @COMPUTATIONAL OPTIONS SELECTED:
000008
000009       @METEOROLOGICAL DATA IDENTIFICATION:
000010          1964 SURFACE DATA FOR NEW ORLEANS, LA + MIXING HEIGHTS FROM LAKE CHARLES, LA
000011
000012
000013
000014
000015        END
000016          35 = NUMBER OF RECEPTORS
000017        ORIGIN AT (X,Y):     50.000      60.000
000018       ANNUAL AVERAGES:REC,RANK,CONC,X,Y,Z
000019            1    11   6.675       .0000       1.200       .0000
000020            2    18   4.214       .0000       1.039       .0000
000021            3    10   8.056       1.039       .0000       .0000
000022            4     4   12.32       1.200       .3045-07    .0000
000023            5     7   10.95       1.039      -.0000       .0000
000024            6     6   11.21       .0000      -1.039       .0000
000025            7     3   12.42       .7341-07   -1.200       .0000
000026            8     2   13.76      -.0000      -1.039       .0000
000027            9     1   15.54      -1.039      -.0000       .0000
000028           10     5   11.44      -1.200      -.1287-06    .0000
000029           11     9   8.772      -1.039       .0000       .0000
000030           12     8   10.20      -.0000       1.039       .0000
000031           13    26   2.635       .4300       6.047       .0000
000032           14    31   1.990       .9123       9.847       .0000
000033           15    34   1.540       2.230       11.16       .0000
000034           16    33   1.772       4.030       11.65       .0000
000035           17    32   1.885       5.830       11.16       .0000
000036           18    29   2.546       7.148       9.847       .0000
000037           19    20   3.724       7.630       8.047       .0000
000038           20    25   3.018      -.8770      -8.492       .0000
000039           21    30   2.143      -1.931      -11.04       .0000
000040           22    28   2.601      -4.477      -12.09       .0000
000041           23    27   2.808      -7.023      -11.04       .0000
000042           24    21   3.624      -8.077      -8.492       .0000
000043           25    24   3.033      -6.954       3.067       .0000
000044           26    15   4.417      -5.060       5.746       .0000
000045           27    16   4.290      -3.167       8.425       .0000
000046           28    13   5.985      -6.759      -2.758       .0000
000047           29    12   6.174      -4.702      -4.191       .0000
000048           30    14   4.882      -2.704      -5.625       .0000
000049           31    22   3.549      -.7670      -7.058       .0000
000050           32    19   3.855       7.047       4.441       .0000
000051           33    35   1.572       6.802      -6.343       .0000
000052           34    17   4.240      -6.905      -6.954       .0000
000053           35    23   3.274      -6.901       4.521       .0000
000054       END
000055       HIGHEST      24-HOUR AVG:REC,RANK,CONC,X,Y,Z,DAY,HOUR
```

NOTE

FORMATS

I5

,2F10.3

2I5,4G10.4

```
      MULTIMAX EXAMPLE CASE 1                                                                        DATE 030377
000056          1   11  81.39     .0000     1.200      .0000            94           .9673
000057          2   23  40.60     .6000     1.039      .0000           117           .9323
000058          3    9  92.49     1.039     .6000      .0000           157           .7367
000059          4    3  124.9     1.200     .3695-07   .0000           339           .9837
000060          5    1  130.9     1.039    -.6000      .0000           292           .9521
000061          6    4  122.5     .6000    -1.039      .0000           325           .9894
000062          7    8  96.88     .7391-07 -1.200      .0000           279           .9743
000063          8   10  88.63    -.6000    -1.039      .0000           273           .9651
000064          9    2  126.5    -1.039    -.6000      .0000           275           .9859
000065         10    6  115.4    -1.200    -.1287-06   .0000           299           .9537
000066         11    5  117.2    -1.039     .6000      .0000            35           .9889
000067         12    7  99.59    -.6000     1.039      .0000            45           .8964
000068         13   32  30.58     .4300     8.047      .0000           227           .8941
000069         14   31  31.68     .9123     9.847      .0000           227           .6941
000070         15   34  27.70     2.230     11.16      .0000             4           .7077
000071         16   29  33.08     4.030     11.65      .0000           228           .9145
000072         17   33  28.68     5.830     11.16      .0000           234           .9043
000073         18   25  40.36     7.148     9.847      .0000           171           .2036
000074         19   18  51.65     7.630     8.047      .0000           322           .7098
000075         20   21  50.09    -.8770    -8.492      .0000           325           .9898
000076         21   26  37.73    -1.931    -11.04      .0000           325           .9894
000077         22   27  37.83    -4.477    -12.09      .0000           341           .7650
000078         23   30  32.28    -7.023    -11.04      .0000           287           .9755
000079         24   20  51.30    -8.077    -8.492      .0000           273           .9651
000080         25   22  46.22    -6.954     3.067      .0000           201           .3200
000081         26   19  51.58    -5.060     5.746      .0000           260           .8164
000082         27   24  41.59    -3.107     8.425      .0000            92           .9906
000083         28   12  73.85    -6.754    -2.758      .0000             5           .9528
000084         29   13  71.06    -4.702    -4.191      .0000           327           .9605
000085         30   15  55.41    -2.764    -5.625      .0000           283           .9521
000086         31   14  58.81    -.7670    -7.058      .0000           325           .9894
000087         32   16  54.31     7.247     4.441      .0000            39           .8464
000088         33   35  20.29     6.802    -6.343      .0000            12           .9250
000089         34   17  53.94    -6.905    -6.954      .0000           273           .9651
000090         35   28  34.32    -6.901     4.521      .0000           320           .8103
000091        END
000092      20 HIGHEST   24-HOUR AVGS(REC,RANK,CONC,X,Y,Z,DAY,MINUM
000093          1   11  75.41     .0000     1.200      .0000           276           .6942
000094          2   21  42.03     .6000     1.039      .0000           227           .8941
000095          3   10  82.02     1.039     .6000      .0000           193           .9727
000096          4    4  107.7     1.200     .3695-07   .0000           324           .9757
000097          5    1  128.4     1.039    -.6000      .0000           334           .9777
000098          6    7  94.85     .6000    -1.039      .0000           278           .9825
000099          7    8  89.88     .7391-07 -1.200      .0000           278           .9825
000100          8    9  83.61    -.6000    -1.039      .0000           284           .8414
000101          9    3  108.3    -1.039    -.6000      .0000           198           .9506
000102         10    5  99.38    -1.200    -.1287-06   .0000             5           .9528
000103         11    2  112.6    -1.039     .6000      .0000            33           .9669
000104         12    6  98.29    -.6000     1.039      .0000           124           .9159
000105         13   29  28.83     .4300     8.047      .0000           129           .8476
000106         14   34  24.60     .9123     9.847      .0000           356           .4111
000107         15   35  22.28     2.230     11.16      .0000           356           .4111
000108         16   26  31.89     4.030     11.65      .0000           169           .9504
000109         17   31  26.70     5.830     11.16      .0000           359           .9673
000110         18   24  33.94     7.148     9.847      .0000           168           .9447
000111         19   19  44.02     7.630     8.047      .0000           163           .4129
000112         20   27  31.48    -.8770    -8.492      .0000           361           .9630
```

2I5,4G10.4,I10,10X,G10.4

2I5 4G10.4,I10,10X,G10.4

```
MULTIMAX EXAMPLE CASE 1                                                                          DATE 030377
000113      21   28   30.11    -1.931     -11.04     .0000        348          .9405
000114      22   33   25.19    -4.477     -12.09     .0000         88          .9054
000115      23   30   29.09    -7.023     -11.04     .0000        341          .7650
000116      24   18   46.21    -8.077     -8.492     .0000        300          .9718
000117      25   20   42.92    -6.954      3.067     .0000        250          .9464
000118      26   16   48.63    -5.060      5.746     .0000        315          .9346
000119      27   22   39.12    -3.167      8.425     .0000        316          .9177
000120      28   13   59.76    -6.759     -2.758     .0000        244          .9537
000121      29   12   69.75    -4.762     -4.191     .0000        310          .7872
000122      30   17   48.09    -2.764     -5.625     .0000        333          .8411
000123      31   23   38.77    -.7670     -7.058     .0000        348          .9405
000124      32   14   51.07     7.247      4.441     .0000         41          .9839
000125      33   32   26.00     6.802     -6.343     .0000         49          .8486
000126      34   15   49.15    -6.905     -6.954     .0000        301          .9621
000127      35   25   33.51    -6.961      4.521     .0000        260          .8164
000128    END
000129    HIGHEST       3-HOUR AVGS,REC,RANK,CONC,X,Y,Z,DAY,HOUR
000130       1    4   416.3     .0000      1.200     .0000        276     14
000131       2   23   223.2     .6000      1.039     .0000        117     14
000132       3    1   484.1     1.039      .6000     .0000        221     13
000133       4    2   441.8     1.200      .3695-07  .0000         85      8
000134       5    3   421.1     1.039     -.6000     .0000        338     14
000135       6   11   320.2     .6000     -1.039     .0000        282     22
000136       7    7   343.1     .7391-07  -1.200     .0000        273     12
000137       8    9   333.6    -.6000     -1.039     .0000        246     14
000138       9    6   352.3    -1.039     -.6000     .0000        187     15
000139      10   12   293.9    -1.200     -.1287-06  .0000        276      1
000140      11    5   359.7    -1.039      .0000     .0000         66     20
000141      12    8   342.2    -.6000      1.039     .0000         45     21
000142      13   31   153.3     .4300      8.047     .0000        169      5
000143      14   32   143.7     .9123      9.847     .0000        212     20
000144      15   25   212.7     2.230      11.16     .0000          4      1
000145      16   30   158.8     4.030      11.65     .0000        169     20
000146      17   26   187.3     5.830      11.16     .0000        170      2
000147      18   28   177.3     7.148      9.847     .0000        322      8
000148      19   20   239.8     7.630      8.047     .0000        322      3
000149      20   34   133.1    -.8770     -8.492     .0000        342     17
000150      21   35   119.7    -1.931     -11.04     .0000         48      4
000151      22   21   238.9    -4.477     -12.09     .0000         88     23
000152      23   27   180.0    -7.023     -11.04     .0000        119     24
000153      24   10   328.9    -8.077     -8.492     .0000        210     19
000154      25   15   288.5    -6.954      3.067     .0000        201      1
000155      26   22   225.3    -5.060      5.746     .0000        309     21
000156      27   16   287.3    -3.167      8.425     .0000        104     22
000157      28   18   264.6    -6.759     -2.758     .0000         69     21
000158      29   13   293.0    -4.762     -4.191     .0000        327     16
000159      30   19   250.7    -2.764     -5.625     .0000        297     18
000160      31   33   135.9    -.7670     -7.058     .0000        282     23
000161      32   14   284.2     7.247      4.441     .0000        247     21
000162      33   29   173.7     6.802     -6.343     .0000        289      2
000163      34   17   267.1    -6.905     -6.954     .0000        210     19
000164      35   24   214.2    -6.961      4.521     .0000        317     21
000165    END
000166    2D HIGHEST    3-HOUR AVGS,REC,RANK,CONC,X,Y,Z,DAY,HOUR
000167       1    5   353.7     .0000      1.200     .0000         70     11
000168       2   17   211.8     .6000      1.039     .0000        132      9
000169       3    1   469.3     1.039      .6000     .0000        157     13
```

2I5, 4G10.4, 2I10

```
      MULTIMAX EXAMPLE CASE 1                                                                                DATE 050377
000170           4    2  418.9    1.200     .3695-07  .0000        153      8
000171           5    3  387.5    1.039    -.6000     .0000        292     12
000172           6    9  313.4     .6000   -1.039     .0000        278      9
000173           7   10  301.5     .7391-07 -1.200    .0000         10      2
000174           8    8  333.4    -.6000   -1.039     .0000         51     13
000175           9    6  389.6   -1.039    -.6000     .0000        264      4
000176          10   12  282.8   -1.200    -.1287-06  .0000          5      6
000177          11    4  359.3   -1.039     .6000     .0000        274     11
000178          12    7  381.6    -.6000    1.039     .0000        103     20
000179          13   28  142.0     .4300    8.047     .0000        227      2
000180          14   30  129.8     .9123    9.847     .0000        227      7
000181          15   33  114.0    2.230     11.16     .0000        186      6
000182          16   26  150.4    4.030     11.65     .0000        227     18
000183          17   24  152.7    5.830     11.16     .0000        200     22
000184          18   23  158.9    7.148     9.847     .0000        171      2
000185          19   16  236.6    7.630     8.047     .0000        167      6
000186          20   32  122.0    -.8770   -8.492     .0000        282     23
000187          21   34  111.1   -1.931    -11.04     .0000        283     19
000188          22   25  151.4   -4.477    -12.09     .0000        380     24
000189          23   29  130.8   -7.023    -11.04     .0000        361     23
000190          24   11  291.6   -8.077    -8.492     .0000        300      3
000191          25   27  149.8   -6.954     3.067     .0000         22      1
000192          26   20  198.4   -5.060     5.746     .0000        109      1
000193          27   14  288.0   -3.167     8.425     .0000        101      5
000194          28   15  238.3   -6.759    -2.758     .0000        176     22
000195          29   19  206.8   -4.762    -4.191     .0000        285      7
000196          30   21  180.9   -2.764    -5.625     .0000        328      3
000197          31   31  126.4    -.7670   -7.058     .0000        283     18
000198          32   13  251.0    7.247     4.441     .0000         39     21
000199          33   35  108.6    6.802    -6.383     .0000        238      3
000200          34   18  211.0   -6.905    -4.958     .0000        265      7
000201          35   22  173.2   -6.461     4.521     .0000        111     23
000202       END
000203       HIGHEST 1-HOUR AVGS:REC,RANK,CONC,X,Y,Z,DAY,HOUR
000204           1    2  623.5     .0000    1.200     .0000        276     14
000205           2    5  584.6     .6000    1.039     .0000        197     15
000206           3    1  656.7    1.039      .6000    .0000        229     13
000207           4    6  584.5    1.200     .3695-07  .0000        242     17
000208           5   14  462.2    1.039    -.6000     .0000        255     22
000209           6   26  393.0     .6000   -1.039     .0000        282     22
000210           7   31  354.2     .7391-07 -1.200    .0000         87     23
000211           8   24  393.7    -.6000   -1.039     .0000        232     15
000212           9    4  588.8   -1.039    -.6000     .0000        196     13
000213          10    3  507.3   -1.200    -.1287-06  .0000         98      9
000214          11   22  402.9   -1.039     .6000     .0000        274     12
000215          12   13  463.7    -.6000    1.039     .0000        250     15
000216          13   29  361.0     .4300    8.047     .0000        212     20
000217          14   25  393.5     .9123    9.847     .0000        212     21
000218          15   33  342.0    2.230     11.16     .0000        186      6
000219          16   18  422.5    4.030     11.65     .0000        227     20
000220          17   15  458.1    5.830     11.16     .0000        200     22
000221          18   10  508.6    7.148     9.847     .0000        322      8
000222          19   17  480.8    7.630     8.047     .0000         31      8
000223          20   35  248.6    -.8770   -8.492     .0000        342     18
000224          21   30  354.2   -1.931    -11.04     .0000         88      4
000225          22   23  399.1   -4.477    -12.09     .0000        164      2
000226          23   12  469.7   -7.023    -11.04     .0000        114     24
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2I5, 4G10.4, 2I10

2I5, 4G10.4, 2I10

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MULTIMAX EXAMPLE CASE 1                                                                          DATE 030377
000227        24    9  514.5    -8.077    -8.492     .0000          210      21
000228        25   19  420.3    -6.954     3.067     .0000          126       6
000229        26   28  364.1    -5.060     5.746     .0000          309      21
000230        27    7  527.9    -3.167     8.425     .0000          101       7
000231        28   21  408.0    -6.759    -2.758     .0000          176      24
000232        29    6  425.6    -4.762    -4.191     .0000          182      22
000233        30   27  377.5    -2.764    -5.025     .0000          163       2
000234        31   32  346.7    -.7670    -7.058     .0000           48       4
000235        32   20  418.7     7.247     4.441     .0000          342       8
000236        33   34  325.7     6.802    -6.343     .0000          238       3
000237        34   11  500.3    -6.905    -6.454     .0000          265       7
000238        35   10  443.7    -6.961     4.521     .0000           18       8
000239       END
000240       1SELECTED TIME PERIODS - ALL RECEPTOR RESULTS
000241       0  24-HOUR AVERAGE TOTAL CONCENTRATIONS AT EACH RECEPTOR FOR DAY 242
000242
000243       0                        --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
000244        REC. RANK  UG/M**3        X,KM       Y,KM   AZIMUTH  RADIUS,KM     X,KM        Y,KM
000245          1   14  .0000          .000      1.200       .00     1.200    50.000      61.200
000246          2   15  .0000          .600      1.039     30.00     1.200    50.600      61.039
000247          3    8  8.198         1.039       .600     60.00     1.200    51.039      60.600
000248          4    2  84.03         1.200       .000     90.00     1.200    51.200      60.000
000249          5    1  187.3         1.039      -.600    120.00     1.200    51.039      59.400
000250          6    3  63.53          .600     -1.039    150.00     1.200    50.600      58.961
000251          7    4  48.45          .000     -1.200    180.00     1.200    50.000      58.800
000252          8   12  .1313-03      -.600     -1.039    210.00     1.200    49.400      58.961
000253          9   16  .0000        -1.039      -.600    240.00     1.200    48.961      59.400
000254         10   17  .0000        -1.200      -.000    270.00     1.200    48.800      60.000
000255         11   18  .0000        -1.039       .600    300.00     1.200    48.961      60.600
000256         12   19  .0000         -.600      1.039    330.00     1.200    49.400      61.039
000257         13   20  .0000          .430      8.047      3.06     8.058    50.430      68.047
000258         14   21  .0000          .912      9.847      5.29     9.889    50.912      69.847
000259         15   22  .0000         2.230     11.165     11.30    11.385    52.230      71.165
000260         16   23  .0000         4.030     11.647     19.09    12.325    54.030      71.647
000261         17   24  .0000         5.830     11.165     27.57    12.595    55.830      71.165
000262         18   25  .0000         7.148      9.847     35.97    12.168    57.148      69.847
000263         19   26  .0000         7.630      8.047     43.48    11.089    57.630      68.047
000264         20    6  33.78         -.877     -8.492    185.90     8.537    49.123      51.508
000265         21    7  12.43        -1.931    -11.038    189.93    11.205    48.069      48.962
000266         22   10  .1705        -4.477    -12.092    200.32    12.894    45.523      47.908
000267         23   13  .7718-09     -7.023    -11.038    212.47    13.082    42.977      48.962
000268         24   27  .0000        -8.077     -8.492    223.57    11.720    41.923      51.508
000269         25   28  .0000        -6.954      3.067    293.80     7.600    43.046      63.067
000270         26   29  .0000        -5.060      5.746    318.63     7.657    44.940      65.746
000271         27   30  .0000        -3.167      8.425    339.40     9.001    46.833      68.425
000272         28   31  .0000        -6.759     -2.758    247.80     7.300    43.241      57.242
000273         29   32  .0000        -4.762     -4.191    228.64     6.344    45.238      55.809
000274         30   11  .1665-02     -2.764     -5.025    208.17     6.267    47.236      54.975
000275         31    5  39.54         -.767     -7.058    186.20     7.100    49.233      52.942
000276         32   33  .0000         7.247      4.441     58.50     8.499    57.247      64.441
000277         33    9  4.894         6.802     -6.343    133.00     9.300    56.802      53.657
000278         34   34  .0000        -6.905     -6.454    224.80     9.800    43.095      53.546
000279         35   35  .0000        -6.961      4.521    303.00     8.300    43.039      64.521
000280       0  24-HOUR AVERAGE TOTAL CONCENTRATIONS AT EACH RECEPTOR FOR DAY 334
000281
000282       0                        --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
000283        REC. RANK  UG/M**3        X,KM       Y,KM   AZIMUTH  RADIUS,KM     X,KM        Y,KM
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2I5, G10.4,2F10.3, F10.2,3F10

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MULTIMAX EXAMPLE CASE 1                                                                                DATE 030377
000284          1   18  .0000         .000     1.200       .00      1.200    50.000    61.200
000285          2   19  .0000         .600     1.039     30.00      1.200    50.600    61.039
000286          3    7  13.77        1.039      .600     60.00      1.200    51.039    60.600
000287          4    2  89.52        1.200      .000     90.00      1.200    51.200    60.000
000288          5    1  143.8        1.039     -.600    120.00      1.200    51.039    59.400
000289          6    4  51.58         .600    -1.039    150.00      1.200    50.600    58.961
000290          7    3  71.65         .000    -1.200    180.00      1.200    50.000    58.800
000291          8   12  2.060        -.600    -1.039    210.00      1.200    49.400    58.961
000292          9   17  .2690-11    -1.039     -.600    240.00      1.200    48.961    59.400
000293         10   20  .0000       -1.200     -.000    270.00      1.200    48.800    60.000
000294         11   21  .0000       -1.039      .600    300.00      1.200    48.961    60.600
000295         12   22  .0000        -.600     1.039    330.00      1.200    49.400    61.039
000296         13   23  .0000         .430     8.047      3.06      8.058    50.430    68.047
000297         14   24  .0000         .912     9.847      5.29      9.889    50.912    69.847
000298         15   25  .0000        2.230    11.165     11.30     11.385    52.230    71.165
000299         16   26  .0000        4.030    11.647     19.09     12.325    54.030    71.647
000300         17   27  .0000        5.830    11.165     27.57     12.595    55.830    71.165
000301         18   28  .0000        7.148     9.847     35.97     12.168    57.148    69.847
000302         19   29  .0000        7.630     8.047     43.48     11.084    57.630    68.047
000303         20    6  14.10        -.877    -8.492    185.90      8.537    49.123    51.508
000304         21    8  11.41       -1.931   -11.038    189.93     11.205    48.069    48.962
000305         22   10  3.415       -4.477   -12.092    200.32     12.894    45.523    47.908
000306         23   13  .3406       -7.023   -11.038    212.47     13.082    42.977    48.962
000307         24   14  .1246-06    -8.077    -8.492    223.57     11.720    41.923    51.508
000308         25   30  .0000       -6.954     3.067    293.80      7.600    43.046    63.067
000309         26   31  .0000       -5.060     5.740    318.63      7.657    44.940    65.740
000310         27   32  .0000       -3.167     8.425    339.40      9.001    46.833    68.425
000311         28   33  .0000       -6.759    -2.758    247.80      7.300    43.241    57.242
000312         29   16  .0343-10    -4.762    -4.191    228.64      6.344    45.238    55.809
000313         30    9  8.423       -2.764    -5.625    206.17      6.267    47.236    54.375
000314         31    5  22.75        -.767    -7.058    186.20      7.100    49.233    52.942
000315         32   34  .0000        7.247     4.441     58.50      8.494    57.247    64.441
000316         33   11  2.723        6.802    -6.343    133.00      9.300    56.802    53.657
000317         34   15  .2402-07    -6.905    -6.954    224.80      9.800    43.095    53.046
000318         35   35  .0000       -6.461     4.521    305.00      8.500    43.539    64.521
000319    0  3-HOUR AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 221 AND HOUR 13
000320
000321    0                       --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
000322     REC. RANK  UG/M**3         X,KM      Y,KM   AZIMUTH  RADIUS,KM      X,KM      Y,KM
000323          1   14  .0000         .000     1.200       .00      1.200    50.000    61.200
000324          2   15  .0000         .600     1.039     30.00      1.200    50.600    61.039
000325          3    1  692.7        1.039      .600     60.00      1.200    51.039    60.600
000326          4    2  328.0        1.200      .000     90.00      1.200    51.200    60.000
000327          5    4  71.91        1.039     -.600    120.00      1.200    51.039    59.400
000328          6    5  64.98         .600    -1.039    150.00      1.200    50.600    58.961
000329          7    3  127.2         .000    -1.200    180.00      1.200    50.000    58.800
000330          8    9  .5603-01     -.600    -1.039    210.00      1.200    49.400    58.961
000331          9   16  .0000       -1.039     -.600    240.00      1.200    48.961    59.400
000332         10   17  .0000       -1.200     -.000    270.00      1.200    48.800    60.000
000333         11   18  .0000       -1.039      .600    300.00      1.200    48.961    60.600
000334         12   19  .0000        -.600     1.039    330.00      1.200    49.400    61.039
000335         13   20  .0000         .430     8.047      3.06      8.058    50.430    68.047
000336         14   21  .0000         .912     9.847      5.29      9.889    50.912    69.847
000337         15   22  .0000        2.230    11.165     11.30     11.385    52.230    71.165
000338         16   23  .0000        4.030    11.647     19.09     12.325    54.030    71.647
000339         17   24  .0000        5.830    11.165     27.57     12.595    55.830    71.165
000340         18   25  .0000        7.148     9.847     35.97     12.168    57.148    69.847
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SAME AS PRECEDING

SAME AS PRECEDING

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MULTIMAX EXAMPLE CASE 1                                                                                    DATE 030377
000341         19   26  .0000        7.630      8.047      43.48     11.089     57.630     68.047
000342         20    7  1.763        -.877     -8.492     185.90      8.537     49.123     51.508
000343         21    8  .4092       -1.931    -11.038     189.93     11.205     48.069     48.962
000344         22   11  .4321-02    -4.477    -12.092     200.32     12.894     45.523     47.908
000345         23   13  .3633-06    -7.023    -11.038     212.47     13.082     42.977     48.962
000346         24   27  .0000       -8.077     -8.492     223.57     11.720     41.923     51.508
000347         25   28  .0000       -6.954      3.067     293.80      7.600     43.046     63.067
000348         26   29  .0000       -5.060      5.746     318.63      7.657     44.940     65.746
000349         27   30  .0000       -3.167      8.425     339.40      9.001     46.833     68.425
000350         28   31  .0000       -6.759     -2.758     247.80      7.300     43.241     57.242
000351         29   32  .0000       -4.762     -4.191     228.64      6.344     45.238     55.809
000352         30   12  .1320-02    -2.764     -5.625     206.17      6.267     47.236     54.375
000353         31    6  2.126        -.767     -7.058     188.20      7.100     49.233     52.942
000354         32   33  .0000        7.247      4.441      58.50      8.499     57.247     64.441
000355         33   10  .3167-01     6.802     -6.343     133.00      9.300     56.802     53.657
000356         34   34  .0000       -6.905     -6.954     224.80      9.800     43.095     53.046
000357         35   35  .0000       -6.961      4.521     303.00      8.300     43.039     64.521
000358      0  3-HOUR AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 157 AND HOUR 13
000359
000360      0                   --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
000361       REC. RANK  UG/M**3       X,KM       Y,KM    AZIMUTH   RADIUS,KM      X,KM       Y,KM
000362          1   18  .0000         .000      1.200        .00      1.200     50.000     61.200
000363          2   19  .0000         .600      1.039      30.00      1.200     50.600     61.039
000364          3    1  671.6        1.039       .600      60.00      1.200     51.039     60.600
000365          4    2  341.3        1.200       .000      90.00      1.200     51.200     60.000
000366          5    4  203.5        1.039      -.600     120.00      1.200     51.039     59.400
000367          6    5  42.87         .600     -1.039     150.00      1.200     50.600     58.961
000368          7    3  338.7         .000     -1.200     180.00      1.200     50.000     58.800
000369          8    9  .3884        -.600     -1.039     210.00      1.200     49.400     58.961
000370          9   16  .3117-12    -1.039      -.600     240.00      1.200     48.961     59.400
000371         10   20  .0000       -1.200      -.000     270.00      1.200     48.800     60.000
000372         11   21  .0000       -1.039       .600     300.00      1.200     48.961     60.600
000373         12   22  .0000        -.600      1.039     330.00      1.200     49.400     61.039
000374         13   23  .0000         .430      8.047       3.06      8.058     50.430     68.047
000375         14   24  .0000         .912      9.847       5.29      9.889     50.912     69.847
000376         15   25  .0000        2.230     11.165      11.30     11.385     52.230     71.165
000377         16   26  .0000        4.030     11.647      19.09     12.325     54.030     71.647
000378         17   27  .0000        5.830     11.165      27.57     12.595     55.830     71.165
000379         18   28  .0000        7.148      9.847      35.97     12.169     57.148     69.847
000380         19   29  .0000        7.630      8.047      43.48     11.089     57.630     68.047
000381         20    7  7.872        -.877     -8.492     185.90      8.537     49.123     51.508
000382         21    8  2.834       -1.931    -11.038     189.93     11.205     48.069     48.962
000383         22   10  .6455-01    -4.477    -12.092     200.32     12.894     45.523     47.908
000384         23   13  .1032-04    -7.023    -11.038     212.47     13.082     42.977     48.962
000385         24   14  .6520-11    -8.077     -8.492     223.57     11.720     41.923     51.508
000386         25   30  .0000       -6.954      3.067     293.80      7.600     43.046     63.067
000387         26   31  .0000       -5.060      5.746     318.63      7.657     44.940     65.746
000388         27   32  .0000       -3.167      8.425     339.40      9.001     46.833     68.425
000389         28   33  .0000       -6.759     -2.758     247.80      7.300     43.241     57.242
000390         29   17  .1123-12    -4.762     -4.191     228.64      6.344     45.238     55.809
000391         30   11  .1800-01    -2.764     -5.625     206.17      6.267     47.236     54.375
000392         31    6  9.510        -.767     -7.058     188.20      7.100     49.233     52.942
000393         32   34  .0000        7.247      4.441      58.50      8.499     57.247     64.441
000394         33   12  .3753-04     6.802     -6.343     133.00      9.300     56.802     53.657
000395         34   15  .3178-11    -6.905     -6.954     224.80      9.800     43.095     53.046
000396         35   35  .0000       -6.961      4.521     303.00      8.300     43.039     64.521
000397      0  1-HOUR AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 229 AND HOUR 13
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SAME AS PRECEDING

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        MULTIMAX EXAMPLE CASE 1                                                                                   DATE 030377

000398
000399         0                                   --- REFERRED TO LOCAL ORIGIN ----------  UNIV. TRANS. MERC
000400          REC. RANK  UG/M**3           X,KM      Y,KM    AZIMUTH  RADIUS,KM      X,KM      Y,KM
000401            1   15   .0000             .000     1.200       .00     1.200      50.000    61.200
000402            2   16   .0000             .600     1.039     30.00     1.200      50.600    61.039
000403            3    1   934.7            1.039      .600     60.00     1.200      51.039    60.600
000404            4    2   153.0            1.200      .000     90.00     1.200      51.200    60.000
000405            5    4   72.13            1.039     -.600    120.00     1.200      51.039    59.400
000406            6    5   36.20             .600    -1.039    150.00     1.200      50.600    58.961
000407            7    3   136.2             .000    -1.200    180.00     1.200      50.000    58.800
000408            8    9   .6248            -.600    -1.039    210.00     1.200      49.400    58.961
000409            9   17   .0000           -1.039     -.600    240.00     1.200      48.961    59.400
000410           10   18   .0000           -1.200     -.000    270.00     1.200      48.800    60.000
000411           11   19   .0000           -1.039      .600    300.00     1.200      48.961    60.600
000412           12   20   .0000            -.600     1.039    330.00     1.200      49.400    61.039
000413           13   21   .0000             .430     8.047      3.06     8.058      50.430    68.047
000414           14   22   .0000             .912     9.847      5.29     9.889      50.912    69.847
000415           15   23   .0000            2.230    11.165     11.30    11.385      52.230    71.165
000416           16   24   .0000            4.030    11.647     19.09    12.325      54.030    71.647
000417           17   25   .0000            5.830    11.165     27.57    12.595      55.830    71.165
000418           18   26   .0000            7.148     9.847     35.97    12.168      57.148    69.847
000419           19   27   .0000            7.630     8.047     43.48    11.089      57.630    68.047
000420           20    7   13.14            -.877    -8.492    185.90     8.537      49.123    51.508
000421           21    8   4.473           -1.931   -11.038    189.93    11.205      48.069    48.962
000422           22   10   .1071           -4.477   -12.092    200.32    12.894      45.523    47.908
000423           23   13   .3848-04        -7.023   -11.038    212.47    13.082      42.977    48.962
000424           24   14   .8101-10        -8.077    -8.492    223.57    11.720      41.923    51.508
000425           25   28   .0000           -6.954     3.067    293.80     7.600      43.046    63.067
000426           26   29   .0000           -5.060     5.746    318.63     7.657      44.940    65.746
000427           27   30   .0000           -3.167     8.425    339.40     9.001      46.833    68.425
000428           28   31   .0000           -6.759    -2.758    247.80     7.300      43.241    57.242
000429           29   32   .0000           -4.762    -4.191    228.64     6.344      45.238    55.809
000430           30   11   .3890-01        -2.764    -5.625    206.17     6.267      47.236    54.375
000431           31    6   14.88            -.767    -7.058    186.20     7.100      49.233    52.942
000432           32   33   .0000            7.247     4.441     58.50     8.499      57.247    64.441
000433           33   12   .7540-07         6.802    -6.343    133.00     9.300      56.802    53.657
000434           34   34   .0000           -6.905    -6.954    224.80     9.800      43.095    53.046
000435           35   35   .0000           -6.961     4.521    303.00     8.300      43.039    64.521
```

SAME AS PRECEDING

(END OF FILE)

## APPENDIX VII

## UNITS-OF-MEASURE CONVERSIONS

Degrees Kelvin = (Deg.F + 459.67)1.8

Meters = Feet * 0.3048

Meters per second = Miles per hour * 0.4470

Feet per second = Miles per hour * 1.467

Grams per second = Pounds per hour * 0.1260

Bars pressure = Atmospheres * 1.0133

Standard Cubic Feet (60$^{\circ}$F, 1 Atm.) = Pound moles * 379.3

Grams per cubic meter = Grams per cubic foot * 35.32

Kilograms = Pounds * 0.45359

Kilocalories = BTU's * 0.252

---

### Parts-per-million volume of a gaseous material;

For one atmosphere pressure, 25°C,

$$\text{PPMV} = (\mu g/m^3 \text{ dispersant}) * 0.02404/M$$

where M is the molecular weight of the dispersant.

For $SO_2$, M = 64, so

$$\text{PPMV} = (\mu g/m^3 \ SO_2) * 3.76E-04$$

## APPENDIX VIII

## MACHINE-DEPENDENT PROGRAM FEATURES

MULTIMAX makes extensive use of re-reads of input cards (Appendices I and II). This is accomplished in the Univac version of the program by making use of the normal reread unit defined normally in the operating system. However, the reread operations were implemented by the TVA by use of their READRE subprogram which reads all second reads of a record from device number 99. Other users may have to implement the reread operation in somewhat different manners, depending upon their particular installation.

Please refer to Appendices I and II for the required file definitions for the two program versions.

Following are brief discussions of most of the Univac Fortran V features used in MULTIMAX which may not be accepted by compilers for other makes of computers, e.g., IBM 370's.

In format statements, A6 fields are used extensively for printing of text. However, most messages and table headings, etc., are printed by subroutine MSGERR.

Logical IF statements containing symbolic strings denoted by apostrophes are used. For example,

```
IF(K.EQ.'DATA') GO TO 233
```

The REREAD logical unit 30 is extensively used for rereading of input cards under different formats than the first one used.

Fortran V allows the use of a PARAMETER specification card. A specified or computed PARAMETER may be used in specifying the size of arrays and a literal constant anywhere in the program. This is very useful for changing the dimensions of many arrays, etc., by only changing a few parameters (such as the maximum number of sources and/or the maximum number of receptors).

The Fortran V INCLUDE statement causes an element in the program file to be temporarily inserted at that point when the element containing the INCLUDE statement(s) is compiled. In most MULTIMAX subroutines and the main program, the statement

```
INCLUDE COMMON
```

causes the element COMMON (see listing) to be inserted. See the listing of element AAAA-DESCRIPTIONS for descriptions of the variables specified in the COMMON element. Note that certain of the variables are initialized in the BLOCK DATA element BLDATA.

Subroutines which are unique to the Univac 1100 systems (some of which may be unique to Shell's computers) are listed in Table 1. These routines and their usages are as follows:

PLEFT, TLEFT and TUSED are used to find the number of output pages remaining available in the run, Central Arithmetic Unit (CAU) seconds already used in the run, respectively. The maximum values of the first two items are defined in the RUN card. These are entry points to the utility element TPARS.

ERTRAN and NERTRN allow the programmer to perform operating system commands without forfeiting control in the program. In subroutine FILGET, the two statements

```
CALL ERTRAN (6, '@ASG,T $TEMP$,F2/1/TRK/200.')
CALL ERTRAN (6, '@USE 31,$TEMP$.')
```

allow the temporary data file $TEMP$ to be used as I/0 logical unit number 31. In the subroutine MSGERR, the statement

```
K = NERTRN(6,'@ADD  LIBRARY*DATA.MULMAX/MSGS.')
```

causes the element MULMAX/MSGS (contained in file LIBRARY*DATA for Shell's library programs) to be inserted in the input "card" run stream. Similar usage is shown in subroutine NEWS.

WBACK causes the jump history to be printed. This generally called in case an error has been detected so that a programmer can track down the reason for the diagnostic.

CALNDR provides the calling routine with the wall clock time and date of run. Its use may be easily seen at the beginning of the main program (element MULMAX).

### TABLE 1

### MACHINE DEPENDENT ROUTINES

| Subroutine | Called By: | Line No. of Call |
|---|---|---|
| PLEFT | ALLMET | 38 |
| TLEFT | ALLPER | 67 |
| | COMPUT | 90 |
| TUSED | COMPUT | 93 |
| ERTRAN | FILGET | 10, 11 |
| NERTRAN | MSGERR | 6 |
| | NEWS | 7 |
| WBACK | MSGERR | 16 |
| | SORT | 28 |
| CALNDR | MULMAX (Main Pgm.) | 10 |

# APPENDIX IX

## EXAMPLE COMPUTER RUN - UNIVAC PROGRAM VERSION

```
@RUN,N  0JHM37,CMS06015400C/MOSER-JH,6041990,005,195          .*WH54JHM2*3798
                                                              06/22/79    07:26:02          *** SEQUENCE NO.  020227 ***

@MSG,N $FROM CMS$ WH54JHM23798 PXF      06/22/79 07:24:32 0 NEW UNIVAC2

@ .

@ .      ***** DELIVER TO : JH MOSER 76

@ .

@HDG  EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

@ASG,AX  MOBILE*ALABAMA
FAC WARNING        040000004001 RELOADED FROM 00:35:01 06/17/79

@ASG,T  SAVE,F2/1/TRK/400

@USE  1,MOBILE*ALABAMA

@USE  2,SAVE

@SYM PRINT$,01,RMOWRC
```

```
 EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                    DATE 062279        PAGE     4
@SPR

@XQT   .MULMAX
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                          DATE 062279        PAGE     5

          MULTIMAX AIR DISPERSION PROGRAM

          RUN ON  22 JUN 1979      7:26:16

*************************************************************************
SEVERAL MODIFICATIONS HAVE BEEN MADE TO THE MULTIMAX PROGRAM WITH
THE MOST CURRENT UPDATE BEING MADE JUNE 1,1978.  INSERT THE NEWS
CONTROL CARD TO GENERATE THIS INFORMATION.
*************************************************************************

----------------- ('*' PRECEDES INPUT RECORDS) -------------------------
*FILES
*MET        1.
*SAVE       2.
*END
*IDENTIFICATION
*EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION
*THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
*NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED
*END
*DATA
(SINCE 'OPTION' RECORD NOT INPUT, PROGRAM WILL USE ALL DEFAULT VALUES.)
*ORIGIN           0.0        0.0
   STACK BASE PLANE ELEVATION =       0. FEET

 NOTE:  IN FOLLOWING, ALL OUTPUT X AND Y COORDINATES FOR LOCATIONS
        ARE IN KILOMETERS REFERRED TO THE LOCAL ORIGIN.

*SOURCES
*SOURCE 1            CART LOCAL       4.7       10.2
   NO.  1            X COORD =     4.700   Y COORD =     10.200
*                       180.0        8.0       20.0      415.0     1600.0
        HT.=    180.00  DIA.=  8.00    VEL.=    20.00
        DEGK=  415.0   EM.RATE=    1600.0     VFR=  1005.

*SOURCE 2            CART LOCAL      -1.2       8.8
   NO.  2            X COORD =    -1.200   Y COORD =      8.800
*                       210.0       10.0       24.5      415.0     1250.0
        HT.=    210.00  DIA.= 10.00    VEL.=    24.50
        DEGK=  415.0   EM.RATE=    1250.0     VFR=  1924.

*ENDEND
*RECEPTORS
*POINT      CART LOCAL      -1.2         9.5
  NO.   1                      X=   -1.200 Y =   9.500 Z=     .0
*POINT      CART LOCAL      -1.2        10.2
  NO.   2                      X=   -1.200 Y =  10.200 Z=     .0
*POINT      CART LOCAL      -4.7         9.5
  NO.   3                      X=   -4.700 Y =   9.500 Z=     .0
*POINT      CART LOCAL      -4.7         8.8
  NO.   4                      X=   -4.700 Y =   8.800 Z=     .0
*CIRCLE     CART LOCAL       1.75        9.5        5.0      16.0      0.0     22
        CENTER AT X =    1.750 Y =    9.500 (LOCAL),  RADIUS =    5.000 KM
        ------ BASIS CIRCLE ------      - LOCAL SYSTEM -
  NO.       DEGREES        X          Y           X          Y          Z
   5            .00       .000      5.000       1.750     14.500        0.
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                          DATE 062279        PAGE    8
     6        22.50     1.913      4.619     3.663    14.119       0.
     7        45.00     3.536      3.536     5.286    13.036       0.
     8        67.50     4.619      1.913     6.369    11.413       0.
     9        90.00     5.000       .000     6.750     9.500       0.
    10       112.50     4.619     -1.913     6.369     7.587       0.
    11       135.00     3.536     -3.536     5.286     5.964       0.
    12       157.50     1.913     -4.619     3.663     4.881       0.
    13       180.00      .000     -5.000     1.750     4.500       0.
    14       202.50    -1.913     -4.619     -.163     4.881       0.
    15       225.00    -3.536     -3.536    -1.786     5.964       0.
    16       247.50    -4.619     -1.913    -2.869     7.587       0.
    17       270.00    -5.000      -.000    -3.250     9.500       0.
    18       292.50    -4.619      1.913    -2.869    11.413       0.
    19       315.00    -3.536      3.536    -1.786    13.036       0.
    20       337.50    -1.913      4.619     -.163    14.119       0.
*CIRCLE     CART LOCAL      1.75        9.5       7.0       16.0        0.0       22
              CENTER AT X =    1.750 Y =    9.500 (LOCAL).  RADIUS =    7.000 KM
              ------ BASIS CIRCLE ------      - LOCAL SYSTEM -
   NO.      DEGREES        X          Y          X          Y          Z
    21          .00      .000      7.000     1.750    16.500       0.
    22        22.50     2.679      6.467     4.429    15.967       0.
    23        45.00     4.950      4.950     6.700    14.450       0.
    24        67.50     6.467      2.679     8.217    12.179       0.
    25        90.00     7.000       .000     8.750     9.500       0.
    26       112.50     6.467     -2.679     8.217     6.821       0.
    27       135.00     4.950     -4.950     6.700     4.550       0.
    28       157.50     2.679     -6.467     4.429     3.033       0.
    29       180.00      .000     -7.000     1.750     2.500       0.
    30       202.50    -2.679     -6.467     -.929     3.033       0.
    31       225.00    -4.950     -4.950    -3.200     4.550       0.
    32       247.50    -6.467     -2.679    -4.717     6.821       0.
    33       270.00    -7.000      -.000    -5.250     9.500       0.
    34       292.50    -6.467      2.679    -4.717    12.179       0.
    35       315.00    -4.950      4.950    -3.200    14.450       0.
    36       337.50    -2.679      6.467     -.929    15.967       0.
*LINE       CART LOCAL     -0.02       9.08       3.52       9.92       4.0
              START X =    -.020 Y =    9.080  END X =    3.520 Y =    9.920
   NO.                     X          Y          Z
    37                   -.020      9.080       .0
    38                   1.160      9.360       .0
    39                   2.340      9.640       .0
    40                   3.520      9.920       .0
*END

   0 INPUT ERRORS DETECTED

*START

METEOROLOGICAL DATA FILE IDENTIFICATION:
1964 HOURLY SURFACE OBSERVATIONS FROM MOBILE,ALA & MIXING DEPTHS FROM LAKE CHA

*****************************************************************
*****************NOTE:  LEAP YEAR DAY IS MISSING*****************
*****************************************************************
YEAR'S CALCULATIONS COMPLETED.  SYSTEM STATUS WRITTEN ON SAVE FILE.
  1.6667    MINUTES USED IN MODEL COMPUTATIONS FOR 365 DAYS.
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                    DATE 062279       PAGE    7

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                   RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION
THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED

COMPUTATIONAL OPTIONS SELECTED:

    CLASSICAL PLUME EQUATION USED
    RECEPTORS ON PLANE: ALL RECEPTOR HEIGHTS SET EQUAL TO ZERO
    WIND SPEED INPUT ADJUSTED TO SOURCE STACK HEIGHTS BY POWER LAW
    RESULTS BASIS TURNER'S SIGMAS (NOT CORRECTED TO ONE HOUR BY POWER LAW)
    STABILITY CLASS LIMIT USED
    RURAL MIXING HEIGHTS USED
    RESULTS NOT ADJUSTED BY CALIBRATION EQUATION.

METEOROLOGICAL DATA IDENTIFICATION:
1964 HOURLY SURFACE OBSERVATIONS FROM MOBILE,ALA & MIXING DEPTHS FROM LAKE CHA



---NOTE:  TALL STACK APPROXIMATION AND THE CLASSICAL PLUME
EQUATION GIVE THE SAME RESULTS FOR PLANE RECEPTORS.---
```

```
                                                                              DATE 062279        PAGE     8
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                   RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

HIGHEST ANNUAL AVERAGES CONCENTRATIONS FOR EACH RECEPTOR
   (IN DESCENDING ORDER)

 RANK    RECEPTOR  UG/M**3

   1         28     1.636
   2         30     1.466
   3         14     1.243
   4         32     1.221
   5         29     1.132
   6         31     1.093
   7         16     1.078
   8         13     1.074
   9         21     1.070
  10         15     1.057
  11          5     1.046
  12         27     1.031
  13         12     1.031
  14         26     1.010
  15         11     1.007
  16         37     .9993
  17         36     .9084
  18         38     .8043
  19         33     .7849
  20          4     .7762
  21         35     .7631
  22          1     .7589
  23          2     .7557
  24          3     .7528
  25         34     .7484
  26         17     .7375
  27         18     .6990
  28         10     .6958
  29          6     .6929
  30         22     .6719
  31         25     .6623
  32         20     .6251
  33         19     .6095
  34         23     .5003
  35         39     .4695
  36         24     .3501
  37          9     .2961
  38          7     .2805
  39         40     .2572
  40          8     .1626
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                              DATE 062279        PAGE    9

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                 RUN STARTED:  22 JUN 1979        7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

HIGHEST 24-HOUR AVERAGE CONCENTRATIONS FOR EACH RECEPTOR

   (IN DESCENDING ORDER)

 RANK    RECEPTOR   UG/M**3    DAY    WIND PERSISTENCE
   1        29       28.91      81        .6552
   2        26       23.62     266        .6394
   3         5       23.23     315        .8798
   4        28       22.90     312        .7554
   5        16       22.59     245        .6794
   6        32       22.48     245        .6794
   7        40       22.07     205        .4309
   8         2       21.74     150        .6666
   9        30       20.77     206        .5212
  10        15       20.38     245        .6794
  11        14       20.02     206        .5212
  12        36       19.22     136        .5100
  13        11       18.65     153        .9437
  14        13       18.57      81        .6552
  15        33       18.35     188        .7007
  16        21       17.86     128        .8500
  17         3       17.03     188        .7007
  18        10       16.78     191        .8734
  19        37       16.49      91        .7864
  20        20       16.20     335        .6260
  21        38       16.14     217        .6883
  22        18       15.99     150        .6666
  23        27       15.92     295        .6054
  24        17       15.72     150        .6666
  25        31       15.48     245        .6794
  26        25       15.03     191        .8734
  27        35       15.02     263        .7348
  28        12       14.76     266        .6394
  29        24       14.59     117        .8609
  30         4       13.82     188        .7007
  31        34       13.57     150        .6666
  32         1       12.84     188        .7007
  33        23       12.83     212        .4236
  34        39       12.70     205        .4309
  35        19       12.01     136        .5100
  36         9       11.64     168        .4907
  37        22       10.64     113        .9641
  38         6       9.716     142        .8246
  39         7       8.191     232        .6258
  40         8       7.106     185        .5709
```

```
                                                                                   DATE 062279       PAGE    10
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                      RUN STARTED:  22 JUN 1979       7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

SECOND HIGHEST 24-HOUR AVERAGE CONCENTRATIONS FOR EACH RECEPTOR

  (IN DESCENDING ORDER)

 RANK   RECEPTOR  UG/M**3    DAY   WIND PERSISTENCE
   1        28     22.02     153        .9437
   2         5     22.01     136        .5100
   3        14     19.17     123        .9526
   4        26     18.83     140        .5748
   5        40     17.26     150        .6666
   6        30     16.76     100        .6022
   7        11     16.71     295        .6054
   8         2     16.09     188        .7007
   9        38     15.92     123        .9526
  10        32     15.41     135        .6452
  11        10     15.39     140        .5748
  12        15     15.31     280        .9526
  13        21     15.29     127        .8811
  14        37     15.09     245        .6794
  15        25     14.72     168        .4907
  16        16     14.65     333        .9321
  17        18     14.57     188        .7007
  18        13     14.42     187        .8713
  19        24     14.39     185        .5709
  20        27     14.35     282        .7413
  21        31     14.22     154        .8116
  22        12     14.19     153        .9437
  23        29     14.13     302        .9843
  24        20     13.80     150        .6666
  25        36     13.50     126        .8997
  26        39     12.50     217        .6883
  27        23     12.38     130        .6623
  28         1     12.22     150        .6666
  29        34     12.02     207        .4995
  30        19     12.00     263        .7348
  31        33     11.78     150        .6666
  32         3     11.52     150        .6666
  33         9     11.08     189        .5779
  34        17     10.87      15        .8396
  35         4     10.29     120        .5892
  36         6     8.844     314        .4635
  37        35     8.750     120        .5892
  38        22     7.820     159        .9142
  39         7     7.651     117        .8609
  40         8     6.137     228        .7943
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                          DATE 062279        PAGE    11

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                     RUN STARTED:  22 JUN 1979        7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

HIGHEST 3-HOUR AVERAGE CONCENTRATION FOR EACH RECEPTOR

  (IN DESCENDING ORDER)

 RANK    RECEPTOR  UG/M**3,  DAY   HOUR
   1        40      176.6    205    12
   2         2      164.7    150    12
   3        28      140.7    231    12
   4        37      131.9     91    11
   5         5      130.2    315    12
   6        21      128.1    128     9
   7        17      122.0    150    12
   8        29      120.5     81    12
   9        11      115.9    295    11
  10        38      115.2    281    10
  11        15      113.5    281    11
  12        16      112.8    333    14
  13        30      110.8    174     8
  14        20      110.3    150     9
  15        27      107.6    295    11
  16        26      107.5    266    15
  17        14      107.3    100    11
  18        32      106.3    333    14
  19        18      106.2    150    12
  20        24      105.7    117    11
  21        13      105.2    187    12
  22        12      102.0    242    11
  23        39      101.6    205    12
  24        25      100.2    189    14
  25        31      97.39    281    10
  26         1      96.89    150    12
  27        36      95.77    136    14
  28        10      94.20    236    11
  29        34      91.58    207    12
  30        33      88.61    150    12
  31        35      88.07    263    12
  32         3      87.10    150    12
  33        23      86.85    130    12
  34        19      82.24    263    12
  35         4      79.33    205    12
  36        22      77.84    113    11
  37         9      77.34    189    14
  38         6      70.74    314    14
  39         7      65.52    232    13
  40         8      46.99    228    10
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                                DATE 062279        PAGE    12

MULTIMAX AIR DISPERSION PROGRAM           SHELL OIL COMPANY
                                      RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

SECOND HIGHEST 3-HOUR AVERAGE CONCENTRATION FOR EACH RECEPTOR

   (IN DESCENDING ORDER)

 RANK   RECEPTOR  UG/M**3,  DAY   HOUR
   1        40     138.1    150    12
   2        28     129.1    242    11
   3         5     122.7    241    10
   4        38     107.8    217    12
   5        14     105.4    246     9
   6        21     104.7    208    11
   7        13     103.1     81    12
   8        37     99.52    281    10
   9        16     98.60    245    14
  10        26     98.07    173    10
  11        11     96.23    281    13
  12        25     95.95    168    11
  13        18     95.18    207    12
  14        32     92.21    245    13
  15        12     88.29    243    15
  16        39     88.07    217    12
  17        10     87.98    190    12
  18        24     87.75    185    10
  19        30     86.97    100    11
  20        34     86.82    150    11
  21         2     85.93    188    10
  22        17     85.12     15    10
  23        36     83.94    257    12
  24        27     83.82    282     9
  25        29     83.80    302    12
  26        33     82.86    188    10
  27         3     82.49     15    10
  28        15     81.90    243     9
  29         1     80.06    257     9
  30        19     77.74    150     9
  31        20     77.51    257    12
  32        31     74.77    243     9
  33         9     73.84    168    11
  34        23     70.63    165    15
  35        35     68.86    297    14
  36         6     65.70    142    13
  37         4     63.94    150    12
  38        22     62.21    247    16
  39         7     60.44    117    11
  40         8     43.88    185    10
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                          DATE 062279        PAGE    13

MULTIMAX AIR DISPERSION PROGRAM            SHELL OIL COMPANY
                                     RUN STARTED:  22 JUN 1979        7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

HIGHEST 1-HOUR CONCENTRATIONS FOR EACH RECEPTOR
   (SORTED IN DESCENDING ORDER)

 RANK    RECEPTOR  UG/M**3    DAY    HOUR
   1        40      451.5     205     12
   2        37      395.6      91     12
   3        38      341.4     281     10
   4        10      281.9     236     12
   5         5      277.5     241     10
   6        11      271.4     163     12
   7        23      260.6     130     12
   8        39      246.1     205     12
   9        21      241.8     158     13
  10         1      240.0     257     10
  11        13      238.9     310     12
  12         4      238.0     205     12
  13        26      235.7     173     10
  14        24      218.6     167     15
  15        28      217.2     242     11
  16        16      211.0     245     14
  17        27      207.1     242     10
  18         2      203.5     150     12
  19        20      201.2     150     10
  20        17      198.5     146     11
  21        25      198.2     228     13
  22        19      197.9     150      9
  23        12      191.5     162     10
  24         7      191.2     232     14
  25        18      189.7     207     13
  26         6      189.1     314     14
  27        35      187.3      26     13
  28        29      182.5      81     10
  29        15      179.4     281     12
  30        14      178.5     246      9
  31        32      176.1     124     15
  32        31      158.0     147     17
  33        22      154.7     203     15
  34        30      152.8     240     10
  35        36      145.0     126      9
  36         3      140.8     257     10
  37        34      135.8     207     12
  38        33      133.2     362     12
  39         9      130.7     189     14
  40         8       88.71    185     11
******************************************************************************
*****************NOTE:  LEAP YEAR DAY IS MISSING*****************
******************************************************************************

CALCULATIONS COMPLETED ON DAY= 365
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EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                    DATE 062279       PAGE    14

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                    RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION
THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED

COMPUTATIONAL OPTIONS SELECTED:

    CLASSICAL PLUME EQUATION USED
    RECEPTORS ON PLANE: ALL RECEPTOR HEIGHTS SET EQUAL TO ZERO
    WIND SPEED INPUT ADJUSTED TO SOURCE STACK HEIGHTS BY POWER LAW
    RESULTS BASIS TURNER'S SIGMAS (NOT CORRECTED TO ONE HOUR BY POWER LAW)
    STABILITY CLASS LIMIT USED
    RURAL MIXING HEIGHTS USED
    RESULTS NOT ADJUSTED BY CALIBRATION EQUATION.

METEOROLOGICAL DATA IDENTIFICATION:
1964 HOURLY SURFACE OBSERVATIONS FROM MOBILE,ALA & MIXING DEPTHS FROM LAKE CHA



---NOTE:  TALL STACK APPROXIMATION AND THE CLASSICAL PLUME
EQUATION GIVE THE SAME RESULTS FOR PLANE RECEPTORS.---

RECEPTOR   28  ANNUAL AVERAGE CONCENTRATION=  1.636

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E       NO.     PERCENT     UG/M**3     RANK
SOURCE 1                1      79.51      1.301         1
SOURCE 2                2      20.49      .3352         2
```

```
                                                                          DATE 062279        PAGE    15
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                   RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

RECEPTOR    29  DAY     AVERAGE CONCENTRATION=  28.91
                DAY =   81

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E        NO.    PERCENT     UG/M**3     RANK
SOURCE 1                 1     94.13      27.22         1
SOURCE 2                 2     5.866      1.696         2
```

```
                                                                                       DATE 062279        PAGE    16
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM            SHELL OIL COMPANY
                                       RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

RECEPTOR   28  DAY    AVERAGE CONCENTRATION=  22.02
               DAY = 153

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E       NO.    PERCENT     UG/M**3     RANK
SOURCE 1               1     100.00      22.02         1
SOURCE 2               2      .7356-05   .1620-05      2
```

```
                                                                                    DATE 062279         PAGE     17
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM            SHELL OIL COMPANY
                                       RUN STARTED:  22 JUN 1979       7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

RECEPTOR    40  3-HOUR AVERAGE CONCENTRATION=  176.6
                DAY = 205 HOUR = 12

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E        NO.    PERCENT     UG/M**3      RANK
SOURCE 1                 1     85.23      150.5          1
SOURCE 2                 2     14.77      26.09          2
```

```
                                                                                     DATE 062279        PAGE    18
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM            SHELL OIL COMPANY
                                    RUN STARTED:  22 JUN 1979       7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

RECEPTOR   40  3-HOUR AVERAGE CONCENTRATION=  138.1
               DAY = 150 HOUR = 12

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

   S O U R C E        NO.     PERCENT     UG/M**3      RANK
SOURCE 1                1     100.00      138.1          1
SOURCE 2                2      .0000      .0000          2
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                    DATE 062279        PAGE    19

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                    RUN STARTED:  22 JUN 1979       7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

RECEPTOR    40  1-HOUR AVERAGE CONCENTRATION=  451.5
                DAY = 205 HOUR = 12

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E        NO.     PERCENT     UG/M**3     RANK
SOURCE 1                 1     100.00      451.5         1
SOURCE 2                 2      .0000      .0000         2
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                    DATE 062279       PAGE    20

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                    RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY =  81      WIND PERSISTENCE =    .655

       STABILITY  WIND SPEED, WIND AZIMUTH,  TEMPERATURE,   MIXING HEIGHT,
HOUR     CLASS    METERS/SEC    DEGREES*      DEGREES C        METERS
  1        D         4.63         215.           5.             1101.
  2        D         3.60         184.           5.             1096.
  3        D         3.60         182.           3.             1091.
  4        D         3.60         147.           3.             1086.
  5        E         2.57         151.           2.             1081.
  6        E         3.09         185.           2.             1076.
  7        E         2.57         162.           2.               91.
  8        D         3.60         186.           3.              226.
  9        C         4.63         218.           6.              361.
 10        C         4.63         199.           7.              496.
 11        C         5.14         188.           8.              631.
 12        B         2.57         205.          10.              766.
 13        C         5.66         198.          12.              901.
 14        C         5.14         201.          14.             1036.
 15        C         5.66         159.          16.             1036.
 16        C         4.12         203.          16.             1036.
 17        C         4.12         221.          17.             1036.
 18        D         2.06         133.          17.             1036.
 19        D         4.12           7.          13.             1035.
 20        D         3.09          44.          11.             1034.
 21        D         3.09          52.          11.             1033.
 22        D         2.06          84.          10.             1031.
 23        E         1.00          85.          10.             1030.
 24        E         1.00          82.           9.             1029.

*  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
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EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                              DATE 062279      PAGE   21

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                   RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY = 150      WIND PERSISTENCE =   .667

       STABILITY  WIND SPEED, WIND AZIMUTH,  TEMPERATURE,  MIXING HEIGHT,
HOUR     CLASS    METERS/SEC    DEGREES*      DEGREES C       METERS
  1        E         2.06         162.          17.             897.
  2        E         2.57         191.          17.             926.
  3        D         3.60         232.          17.             954.
  4        E         3.09         272.          16.             983.
  5        E         2.57         231.          16.            1012.
  6        E         3.09         266.          15.             105.
  7        D         3.60         261.          16.             251.
  8        D         5.14         314.          18.             397.
  9        C         4.12         293.          21.             542.
 10        B         3.60         308.          22.             688.
 11        B         4.63         308.          23.             834.
 12        A         2.06         275.          25.             980.
 13        A         2.57         273.          26.            1126.
 14        B         3.09         270.          28.            1272.
 15        C         2.06         275.          30.            1272.
 16        C         4.12          32.          28.            1272.
 17        C         1.00          27.          27.            1272.
 18        D         2.57         358.          27.            1272.
 19        D         3.60         232.          26.            1272.
 20        D         2.57         341.          25.            1243.
 21        D         2.57         289.          24.            1211.
 22        D         2.06         217.          23.            1180.
 23        E         3.09         224.          22.            1149.
 24        E         2.57         266.          21.            1118.

*  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
```

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                                                                                DATE 062279       PAGE    22
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                    RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY = 153      WIND PERSISTENCE =   .944

      STABILITY   WIND SPEED,  WIND AZIMUTH,   TEMPERATURE,    MIXING HEIGHT,
HOUR    CLASS     METERS/SEC     DEGREES*       DEGREES C         METERS
  1       E          3.09          150.            17.             1284.
  2       E          2.06          151.            16.             1319.
  3       E          2.06          164.            16.             1354.
  4       E          3.09          150.            16.             1390.
  5       E          2.06          158.            16.             1425.
  6       E          3.09          150.            16.              146.
  7       D          3.09          155.            16.              346.
  8       C          4.63          176.            18.              545.
  9       B          3.60          162.            21.              745.
 10       C          4.63          188.            23.              945.
 11       C          5.14          179.            25.             1145.
 12       B          4.12          200.            26.             1344.
 13       C          5.14          194.            26.             1544.
 14       B          3.60          175.            27.             1744.
 15       C          4.12          160.            28.             1744.
 16       C          5.14          225.            28.             1744.
 17       C          4.12          183.            28.             1744.
 18       C          4.12          178.            28.             1744.
 19       D          5.14          179.            27.             1744.
 20       D          2.57          185.            24.             1750.
 21       D          3.60          176.            23.             1758.
 22       D          3.60          178.            22.             1765.
 23       D          3.60          204.            21.             1772.
 24       D          3.09          203.            21.             1779.

*  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
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EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                              DATE 062279        PAGE   23

MULTIMAX AIR DISPERSION PROGRAM             SHELL OIL COMPANY
                                     RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY = 205       WIND PERSISTENCE =   .431

        STABILITY  WIND SPEED, WIND AZIMUTH,   TEMPERATURE,    MIXING HEIGHT,
HOUR      CLASS    METERS/SEC    DEGREES*       DEGREES C         METERS
  1         E         2.57          83.            23.            1197.
  2         D         4.12          92.            23.            1204.
  3         D         2.06          90.            22.            1212.
  4         D         3.09          91.            22.            1219.
  5         D         3.09         124.            22.            1226.
  6         E         3.09         124.            23.            1233.
  7         D         3.09         135.            23.            1241.
  8         C         3.60         158.            26.            1248.
  9         C         4.12         144.            28.            1255.
 10         B         3.09         138.            29.            1262.
 11         B         4.12         182.            31.            1269.
 12         A         2.57         264.            31.            1277.
 13         B         3.09          74.            31.            1284.
 14         C         2.57         355.            31.            1291.
 15         D         5.14          57.            26.            1291.
 16         D         3.09          86.            26.            1291.
 17         D         2.06         230.            25.            1291.
 18         C         1.00         229.            26.            1291.
 19         D         3.09         359.            26.            1291.
 20         D         4.12         204.            26.            1271.
 21         D         2.06         158.            25.            1248.
 22         D         2.57         233.            24.            1225.
 23         D         3.60         194.            23.            1202.
 24         C         2.57         319.            23.            1179.

*  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
****************************************************************************
*****************NOTE:  LEAP YEAR DAY IS MISSING*****************
****************************************************************************

SELECTED TIMES - RECEPTOR CALCULATIONS  COMPLETED ON DAY= 205
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                                                                              DATE 062279         PAGE    24
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                   RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION
THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED

COMPUTATIONAL OPTIONS SELECTED:

     CLASSICAL PLUME EQUATION USED
     RECEPTORS ON PLANE: ALL RECEPTOR HEIGHTS SET EQUAL TO ZERO
     WIND SPEED INPUT ADJUSTED TO SOURCE STACK HEIGHTS BY POWER LAW
     RESULTS BASIS TURNER'S SIGMAS (NOT CORRECTED TO ONE HOUR BY POWER LAW)
     STABILITY CLASS LIMIT USED
     RURAL MIXING HEIGHTS USED
     RESULTS NOT ADJUSTED BY CALIBRATION EQUATION.

METEOROLOGICAL DATA IDENTIFICATION:
1964 HOURLY SURFACE OBSERVATIONS FROM MOBILE,ALA & MIXING DEPTHS FROM LAKE CHA



---NOTE:  TALL STACK APPROXIMATION AND THE CLASSICAL PLUME
EQUATION GIVE THE SAME RESULTS FOR PLANE RECEPTORS.---

  24-HOUR AVERAGE TOTAL CONCENTRATIONS AT EACH RECEPTOR FOR DAY  81

                          --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3          X,KM      Y,KM   AZIMUTH  RADIUS,KM     X,KM       Y,KM
   1   34  .0000          -1.200     9.500    352.80     9.575
   2   33  .1412-27       -1.200    10.200    353.29    10.270
   3   35  .0000          -4.700     9.500    333.68    10.599
   4   36  .0000          -4.700     8.800    331.89     9.976
   5   31  .3337-14        1.750    14.500      6.88    14.605
   6   22  .6900-07        3.663    14.119     14.55    14.587
   7   21  .1067-06        5.286    13.036     22.07    14.066
   8   25  .5072-11        6.369    11.413     29.16    13.070
   9   19  .5570-06        6.750     9.500     35.39    11.654
  10    9  .2216           6.369     7.587     40.02     9.906
  11   10  .1962           5.286     5.964     41.55     7.969
  12    3  11.47           3.663     4.881     36.89     6.103
  13    2  18.57           1.750     4.500     21.25     4.828
  14    4  5.822           -.163     4.881    358.08     4.883
  15   11  .1779          -1.786     5.964    343.33     6.226
  16   17  .1116-04       -2.869     7.587    339.28     8.111
  17   37  .0000          -3.250     9.500    341.11    10.041
  18   38  .0000          -2.869    11.413    345.89    11.769
  19   30  .1008-13       -1.786    13.036    352.20    13.157
  20   20  .1102-06        -.163    14.119    359.34    14.120
  21   23  .9008-08        1.750    16.500      6.05    16.593
  22   13  .2648-04        4.429    15.967     15.50    16.570
  23   15  .1611-04        6.700    14.450     24.88    15.927
  24   24  .4753-09        8.217    12.179     34.01    14.692
```

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EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                                    DATE 062279        PAGE    25

  25   14  .1933-04      8.750       9.500      42.65     12.916
  26   18  .5332-05      8.217       6.821      50.30     10.679
  27    6  5.110         6.700       4.550      55.82      8.099
  28    7  2.819         4.429       3.033      55.60      5.368
  29    1  28.91         1.750       2.500      34.99      3.052
  30    5  5.287         -.929       3.033     342.97      3.172
  31    8  2.259        -3.200       4.550     324.89      5.563
  32   12  .1100-03     -4.717       6.821     325.33      8.293
  33   39  .0000        -5.250       9.500     331.07     10.854
  34   40  .0000        -4.717      12.179     338.83     13.060
  35   32  .1975-22     -3.200      14.450     347.51     14.800
  36   16  .1262-04      -.929      15.967     356.67     15.994
  37   28  .6580-13      -.020       9.080     359.87      9.080
  38   27  .1130-12      1.160       9.360       7.06      9.432
  39   29  .2095-13      2.340       9.640      13.64      9.920
  40   26  .1193-12      3.520       9.920      19.54     10.526
```

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EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                              DATE 062279        PAGE    28

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                   RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

  24-HOUR AVERAGE TOTAL CONCENTRATIONS AT EACH RECEPTOR FOR DAY 153

                        --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3         X,KM       Y,KM   AZIMUTH  RADIUS,KM     X,KM        Y,KM
   1   20  .5126-16      -1.200      9.500    352.80     9.575
   2   22  .0000         -1.200     10.200    353.29    10.270
   3   23  .0000         -4.700      9.500    333.68    10.599
   4   19  .9922-16      -4.700      8.800    331.89     9.976
   5   24  .0000          1.750     14.500      6.88    14.605
   6   25  .0000          3.663     14.119     14.55    14.587
   7   26  .0000          5.286     13.036     22.07    14.066
   8   27  .0000          6.369     11.413     29.16    13.070
   9   28  .0000          6.750      9.500     35.39    11.654
  10   11  1.385          6.369      7.587     40.02     9.906
  11    2  18.65          5.286      5.964     41.55     7.969
  12    3  14.19          3.663      4.881     36.89     6.103
  13    9  2.556          1.750      4.500     21.25     4.828
  14    6  6.282          -.163      4.881    358.08     4.883
  15   10  1.928         -1.786      5.964    343.33     6.226
  16   14  .1508-02      -2.869      7.587    339.28     8.111
  17   21  .2299-19      -3.250      9.500    341.11    10.041
  18   29  .0000         -2.869     11.413    345.89    11.769
  19   30  .0000         -1.786     13.036    352.20    13.157
  20   31  .0000          -.163     14.119    359.34    14.120
  21   32  .0000          1.750     16.500      6.05    16.593
  22   33  .0000          4.429     15.967     15.50    16.570
  23   34  .0000          6.700     14.450     24.88    15.927
  24   35  .0000          8.217     12.179     34.01    14.692
  25   36  .0000          8.750      9.500     42.65    12.916
  26   13  .2205-02       8.217      6.821     50.30    10.679
  27    4  14.09          6.700      4.550     55.82     8.099
  28    1  22.02          4.429      3.033     55.60     5.368
  29    7  6.088          1.750      2.500     34.99     3.052
  30    5  9.313          -.929      3.033    342.97     3.172
  31    8  3.315         -3.200      4.550    324.89     5.563
  32   12  .7683-02      -4.717      6.821    325.33     8.293
  33   37  .0000         -5.250      9.500    331.07    10.854
  34   38  .0000         -4.717     12.179    338.83    13.060
  35   39  .0000         -3.200     14.450    347.51    14.800
  36   40  .0000          -.929     15.967    356.67    15.994
  37   17  .3359-09       -.020      9.080    359.87     9.080
  38   15  .6698-09       1.160      9.360      7.06     9.432
  39   16  .3456-09       2.340      9.640     13.64     9.920
  40   18  .2810-11       3.520      9.920     19.54    10.526
```

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EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                          DATE 062279        PAGE   27

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                      RUN STARTED:  22 JUN 1979      7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

  3-HOUR AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 205 AND HOUR 12

                        --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3          X,KM      Y,KM    AZIMUTH  RADIUS,KM    X,KM        Y,KM
   1    5  47.33          -1.200     9.500    352.80     9.575
   2   10  39.31          -1.200    10.200    353.29    10.270
   3    6  44.38          -4.700     9.500    333.68    10.599
   4    3  79.33          -4.700     8.800    331.89     9.976
   5   34  .2584-07        1.750    14.500      6.88    14.605
   6   21  1.097           3.663    14.119     14.55    14.587
   7   22  1.085           5.286    13.036     22.07    14.066
   8   13  23.40           6.369    11.413     29.16    13.070
   9   17  7.113           6.750     9.500     35.39    11.654
  10   28  .1945-01        6.369     7.587     40.02     9.906
  11   35  .1659-07        5.286     5.964     41.55     7.969
  12   37  .0000           3.663     4.881     36.89     6.103
  13   38  .0000           1.750     4.500     21.25     4.828
  14   32  .4883-04        -.163     4.881    358.08     4.883
  15   24  .2906          -1.786     5.964    343.33     6.226
  16   14  14.39          -2.869     7.587    339.28     8.111
  17    9  41.88          -3.250     9.500    341.11    10.041
  18   16  9.644          -2.869    11.413    345.89    11.769
  19   23  .4151          -1.786    13.036    352.20    13.157
  20   29  .8999-02        -.163    14.119    359.34    14.120
  21   30  .3828-02        1.750    16.500      6.05    16.593
  22   12  24.25           4.429    15.967     15.50    16.570
  23   25  .2599           6.700    14.450     24.88    15.927
  24   11  30.26           8.217    12.179     34.01    14.692
  25   18  4.383           8.750     9.500     42.65    12.916
  26   31  .1456-02        8.217     6.821     50.30    10.679
  27   36  .1236-11        6.700     4.550     55.82     8.099
  28   39  .0000           4.429     3.033     55.60     5.368
  29   40  .0000           1.750     2.500     34.99     3.052
  30   33  .1383-06        -.929     3.033    342.97     3.172
  31   26  .5551-01       -3.200     4.550    324.89     5.563
  32   15  11.76          -4.717     6.821    325.33     8.293
  33    7  43.88          -5.250     9.500    331.07    10.854
  34   19  3.889          -4.717    12.179    338.83    13.060
  35   27  .4806-01       -3.200    14.450    347.51    14.800
  36   20  2.754           -.929    15.967    356.67    15.994
  37    8  42.88           -.020     9.080    359.87     9.080
  38    4  59.76           1.160     9.360      7.06     9.432
  39    2  101.6           2.340     9.640     13.64     9.920
  40    1  176.6           3.520     9.920     19.54    10.526
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                            DATE 062279        PAGE   28

MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY
                                   RUN STARTED:  22 JUN 1979       7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

  3-HOUR AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 150 AND HOUR 12

                          --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3          X,KM      Y,KM   AZIMUTH  RADIUS,KM      X,KM      Y,KM
   1    5  96.89          -1.200     9.500    352.80     9.575
   2    1  164.7          -1.200    10.200    353.29    10.270
   3    7  87.10          -4.700     9.500    333.68    10.599
   4   10  63.94          -4.700     8.800    331.89     9.976
   5   22  .0000           1.750    14.500      6.88    14.605
   6   23  .0000           3.663    14.119     14.55    14.587
   7   24  .0000           5.286    13.036     22.07    14.066
   8   25  .0000           6.369    11.413     29.16    13.070
   9   26  .0000           6.750     9.500     35.39    11.654
  10   27  .0000           6.369     7.587     40.02     9.906
  11   28  .0000           5.286     5.964     41.55     7.969
  12   29  .0000           3.663     4.881     36.89     6.103
  13   30  .0000           1.750     4.500     21.25     4.828
  14   21  .1122-13        -.163     4.881    358.08     4.883
  15   18  .3842-02       -1.786     5.964    343.33     6.226
  16   14  3.961          -2.869     7.587    339.28     8.111
  17    3  122.0          -3.250     9.500    341.11    10.041
  18    4  106.2          -2.869    11.413    345.89    11.769
  19   13  11.85          -1.786    13.036    352.20    13.157
  20   17  .4066-01        -.163    14.119    359.34    14.120
  21   31  .0000           1.750    16.500      6.05    16.593
  22   32  .0000           4.429    15.967     15.50    16.570
  23   33  .0000           6.700    14.450     24.88    15.927
  24   34  .0000           8.217    12.179     34.01    14.692
  25   35  .0000           8.750     9.500     42.65    12.916
  26   36  .0000           8.217     6.821     50.30    10.679
  27   37  .0000           6.700     4.550     55.82     8.099
  28   38  .0000           4.429     3.033     55.60     5.368
  29   39  .0000           1.750     2.500     34.99     3.052
  30   40  .0000           -.929     3.033    342.97     3.172
  31   19  .2361-03       -3.200     4.550    324.89     5.563
  32   15  1.999          -4.717     6.821    325.33     8.293
  33    6  88.61          -5.250     9.500    331.07    10.854
  34    9  65.92          -4.717    12.179    338.83    13.060
  35   16  1.969          -3.200    14.450    347.51    14.800
  36   20  .1133-03        -.929    15.967    356.67    15.994
  37   12  40.52           -.020     9.080    359.87     9.080
  38   11  56.43           1.160     9.360      7.06     9.432
  39    8  80.66           2.340     9.640     13.64     9.920
  40    2  138.1           3.520     9.920     19.54    10.526
```

```
EXAMPLE CASE FOR UNIVAC 1110 VERSION USING MOBILE*ALABAMA DATA                                  DATE 062279        PAGE   29

MULTIMAX AIR DISPERSION PROGRAM              SHELL OIL COMPANY
                                      RUN STARTED:  22 JUN 1979        7:26:16

PROBLEM TITLE:

EXAMPLE RUN OF MULTIMAX - SAME AS IBM COMPATIBLE VERSION

  1-HOUR AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 205 AND HOUR 12


                           --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3           X,KM       Y,KM   AZIMUTH  RADIUS,KM     X,KM        Y,KM
   1    5  142.0           -1.200      9.500    352.80      9.575
   2   10  117.9           -1.200     10.200    353.29     10.270
   3    6  133.1           -4.700      9.500    333.68     10.599
   4    3  238.0           -4.700      8.800    331.89      9.976
   5   22  .0000            1.750     14.500      6.88     14.605
   6   23  .0000            3.663     14.119     14.55     14.587
   7   24  .0000            5.286     13.036     22.07     14.066
   8   25  .0000            6.369     11.413     29.16     13.070
   9   26  .0000            6.750      9.500     35.39     11.654
  10   27  .0000            6.369      7.587     40.02      9.906
  11   28  .0000            5.286      5.964     41.55      7.969
  12   29  .0000            3.663      4.881     36.89      6.103
  13   30  .0000            1.750      4.500     21.25      4.828
  14   19  .1465-03         -.163      4.881    358.08      4.883
  15   15  .8718           -1.786      5.964    343.33      6.226
  16   11  43.18           -2.869      7.587    339.28      8.111
  17    9  125.7           -3.250      9.500    341.11     10.041
  18   13  28.93           -2.869     11.413    345.89     11.769
  19   16  .3735           -1.786     13.036    352.20     13.157
  20   20  .1182-04         -.163     14.119    359.34     14.120
  21   31  .0000            1.750     16.500      6.05     16.593
  22   32  .0000            4.429     15.967     15.50     16.570
  23   33  .0000            6.700     14.450     24.88     15.927
  24   34  .0000            8.217     12.179     34.01     14.692
  25   35  .0000            8.750      9.500     42.65     12.916
  26   36  .0000            8.217      6.821     50.30     10.679
  27   37  .0000            6.700      4.550     55.82      8.099
  28   38  .0000            4.429      3.033     55.60      5.368
  29   39  .0000            1.750      2.500     34.99      3.052
  30   21  .4149-06         -.929      3.033    342.97      3.172
  31   17  .1665           -3.200      4.550    324.89      5.563
  32   12  35.27           -4.717      6.821    325.33      8.293
  33    7  131.7           -5.250      9.500    331.07     10.854
  34   14  11.67           -4.717     12.179    338.83     13.060
  35   18  .1509-01        -3.200     14.450    347.51     14.800
  36   40  .0000            -.929     15.967    356.67     15.994
  37    8  128.6            -.020      9.080    359.87      9.080
  38    4  168.4            1.160      9.360      7.06      9.432
  39    2  246.1            2.340      9.640     13.64      9.920
  40    1  451.5            3.520      9.920     19.54     10.526
*STOP

PROGRAM MULTIMAX OPERATIONS COMPLETED NORMALLY.
```

```
@SPR

@FIN
```

# APPENDIX X

## EXAMPLE COMPUTER RUN - IBM PROGRAM VERSION

```
IAT6140 JOB ORIGIN FROM GROUP=RMT48    , DSP=CR , DEVICE=RMT48RD1, 033
13:08:23 IAT4401  LOCATE FOR STEP=STEP1    DD=STEPLIB  DSN=T0821000.TEST.LOADLIB
13:08:24 IAT4402 UNIT=3330-1  ,VOL(S)=SCR305
13:08:25 IAT4401  LOCATE FOR STEP=STEP1    DD=FT09F001 DSN=T0821000.MET3.DATA
13:08:25 IAT4402 UNIT=3330-1  ,VOL(S)=SCR135
13:08:47 IAT5110 JOB 8321 (CHS44LIB) USES D SCR305 T0821000.TEST.LOADLI
13:08:47 IAT5110 JOB 8321 (CHS44LIB) USES D SCR135 T0821000.MET3.DATA
13:26:29 IAT5200 JOB 8321 (CHS44LIB) IN SETUP ON MAIN=S683
13:26:29 IAT5210 STEPLIB  USING D SCR305 ON 2A1 T0821000.TEST.LOADLI
13:26:29 IAT5210 FT09F001 USING D SCR135 ON 791 T0821000.MET3.DATA
13:27:06 IAT2000 JOB 8321 CHS44LIB SELECTED S683     GRP=REMPROD
13:27:07 S683 R= CHS44LIB IEF403I CHS44LIB - STARTED - TIME=13.27.09
13:33:12 S683 R= CHS44LIB IEF404I CHS44LIB - ENDED - TIME=13.33.07
13:35:36 IAT5400 JOB 8321 (CHS44LIB) IN BREAKDOWN
```

```
//CHS44LIB JOB (P0058026,T20,058026,01300638,R0166HP,7H06,10,999),
//     'US01DATA97755T-8-228',CLASS=R,NOTIFY=C058026
//*    $FROM CMS$ US01DATA9999 MULMAX   06/22/79 13:07:41 0
//*         SAMPLE JOB STREAM FOR EXECUTING IBM COMPATIBLE VERSION
//*         OF MULTIMAX FROM A LOAD MODULE - USING MOBILE*ALABAMA
//*         MET DATA AS INPUT ON UNIT 9
//STEP1    EXEC PGM=MULMAX,REGION=300K
//STEPLIB DD DSN=T0821000.TEST.LOADLIB,DISP=SHR
//FT05F001  DD DDNAME=SYSIN
//FT06F001  DD SYSOUT=A
//FT07F001  DD SYSOUT=B
//FT09F001  DD DSN=T0821000.MET3.DATA,DISP=SHR
//SYSIN DD *,DCB=BLKSIZE=80
/*
//
    1     //CHS44LIB JOB (P0058026,T20,058026,01300638,R0166HP,7H06,10,999),
          //     'US01DATA97755T-8-228',CLASS=R,NOTIFY=C058026
          ***    $FROM CMS$ US01DATA9999 MULMAX   06/22/79 13:07:41 0
          ***         SAMPLE JOB STREAM FOR EXECUTING IBM COMPATIBLE VERSION
          ***         OF MULTIMAX FROM A LOAD MODULE - USING MOBILE*ALABAMA
          ***         MET DATA AS INPUT ON UNIT 9
    2     //STEP1    EXEC PGM=MULMAX,REGION=300K
    3     //STEPLIB DD DSN=T0821000.TEST.LOADLIB,DISP=SHR
    4     //FT05F001  DD DDNAME=SYSIN
    5     //FT06F001  DD SYSOUT=A
    6     //FT07F001  DD SYSOUT=B
    7     //FT09F001  DD DSN=T0821000.MET3.DATA,DISP=SHR
    8     //SYSIN DD *,DCB=BLKSIZE=80
          //
```

```
IEF236I ALLOC. FOR CHS44LIB STEP1
IEF237I 2A1  ALLOCATED TO STEPLIB
IEF237I 85E  ALLOCATED TO SYS01112
IEF237I JES3 ALLOCATED TO FT05F001
IEF237I JES3 ALLOCATED TO FT06F001
IEF237I JES3 ALLOCATED TO FT07F001
IEF237I 791  ALLOCATED TO FT09F001
IEF142I CHS44LIB STEP1 - STEP WAS EXECUTED - COND CODE 0000
IEF285I   T0821000.TEST.LOADLIB                        KEPT
IEF285I   VOL SER NOS= SCR305.
IEF285I   SYSCTLG.VDATA02                              KEPT
IEF285I   VOL SER NOS= DATA02.
IEF285I   JESI0001                                     SYSIN
IEF285I   STEP1.FT06F001                               SYSOUT
IEF285I   STEP1.FT07F001                               SYSOUT
IEF285I   T0821000.MET3.DATA                           KEPT
IEF285I   VOL SER NOS= SCR135.
 XXXXX    STEP STEP1       ENDED AT  13.33.07    HWM 0272K    CPU TIME 0128SEC    REGION  0300K    CORE TIME CHARGE      1.03    XXXXX
 XXXXX    COMP CODE 000    COND CODE 0000        VOLUNTARY WAIT TIME 00043SEC    TAPE 00 UNITS     TAPE TIME CHARGE       .00    XXXXX
 XXXXX                                                                                        CHANNEL TIME CHARGE       .23    XXXXX
```

```
*IDENTIFICATION
*TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION
*THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
*NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED
*END
*DATA
(SINCE 'OPTION' RECORD NOT INPUT, PROGRAM WILL USE ALL DEFAULT VALUES.)
*ORIGIN             0.0         0.0
   STACK BASE PLANE ELEVATION =       0. FEET
 NOTE:  IN FOLLOWING, ALL OUTPUT X AND Y COORDINATES FOR LOCATIONS
        ARE IN KILOMETERS REFERRED TO THE LOCAL ORIGIN.

*SOURCES
*SOURCE 1             CART LOCAL       4.7       10.2
   NO.  1             X COORD =      4.700   Y COORD =     10.200
*                          180.0        8.0       20.0      415.0     1600.0
         HT.=    180.00  DIA.=  8.00    VEL.=   20.00
         DEGK=  415.0    EM.RATE=  1600.0        VFR= 1005.

*SOURCE 2             CART LOCAL      -1.2        8.8
   NO.  2             X COORD =     -1.200   Y COORD =      8.800
*                          210.0       10.0       24.5      415.0     1250.0
         HT.=    210.00  DIA.= 10.00    VEL.=   24.50
         DEGK=  415.0    EM.RATE=  1250.0        VFR= 1924.

*ENDEND
*RECEPTORS
*POINT      CART LOCAL      -1.2        9.5
  NO.   1                     X=   -1.200 Y =    9.500 Z=     0.0
*POINT      CART LOCAL      -1.2       10.2
  NO.   2                     X=   -1.200 Y =   10.200 Z=     0.0
*POINT      CART LOCAL      -4.7        9.5
  NO.   3                     X=   -4.700 Y =    9.500 Z=     0.0
*POINT      CART LOCAL      -4.7        8.8
  NO.   4                     X=   -4.700 Y =    8.800 Z=     0.0
*CIRCLE     CART LOCAL      1.75        9.5        5.0       16.0        0.0      22
          CENTER AT X =    1.750 Y =    9.500 (LOCAL),  RADIUS =    5.000 KM
          ------ BASIS CIRCLE ------      - LOCAL SYSTEM -
  NO.       DEGREES        X          Y          X          Y          Z
   5          0.0        0.0      5.000      1.750     14.500         0.
   6         22.50      1.913      4.619      3.663     14.119         0.
   7         45.00      3.536      3.536      5.286     13.036         0.
   8         67.50      4.619      1.913      6.369     11.413         0.
   9         90.00      5.000      0.000      6.750      9.500         0.
  10        112.50      4.619     -1.913      6.369      7.587         0.
  11        135.00      3.536     -3.536      5.286      5.964         0.
  12        157.50      1.913     -4.619      3.663      4.881         0.
  13        180.00      0.000     -5.000      1.750      4.500         0.
  14        202.50     -1.913     -4.619     -0.163      4.881         0.
  15        225.00     -3.536     -3.536     -1.786      5.964         0.
  16        247.50     -4.619     -1.913     -2.869      7.587         0.
  17        270.00     -5.000      0.000     -3.250      9.500         0.
  18        292.50     -4.619      1.913     -2.869     11.413         0.
  19        315.00     -3.536      3.536     -1.786     13.036         0.
  20        337.50     -1.913      4.619     -0.163     14.119         0.
*CIRCLE     CART LOCAL      1.75        9.5        7.0       16.0        0.0      22
          CENTER AT X =    1.750 Y =    9.500 (LOCAL),  RADIUS =    7.000 KM
          ------ BASIS CIRCLE ------      - LOCAL SYSTEM -
  NO.       DEGREES        X          Y          X          Y          Z
  21          0.0        0.0      7.000      1.750     16.500         0.
  22        22.50     2.679     6.467     4.429    15.967        0.
  23        45.00     4.950     4.950     6.700    14.450        0.
  24        67.50     6.467     2.679     8.217    12.179        0.
  25        90.00     7.000     0.000     8.750     9.500        0.
  26       112.50     6.467    -2.679     8.217     6.821        0.
  27       135.00     4.950    -4.950     6.700     4.550        0.
  28       157.50     2.679    -6.467     4.429     3.033        0.
  29       180.00     0.000    -7.000     1.750     2.500        0.
  30       202.50    -2.679    -6.467    -0.929     3.033        0.
  31       225.00    -4.950    -4.950    -3.200     4.550        0.
  32       247.50    -6.467    -2.679    -4.717     6.821        0.
  33       270.00    -7.000     0.000    -5.250     9.500        0.
  34       292.50    -6.467     2.679    -4.717    12.179        0.
  35       315.00    -4.950     4.950    -3.200    14.450        0.
  36       337.50    -2.679     6.467    -0.929    15.967        0.
*LINE      CART LOCAL     -0.02      9.08      3.52      9.92       4.0
           START X =  -0.020 Y =    9.080  END X =   3.520 Y =    9.920
  NO.                   X         Y         Z
  37                -0.020     9.080      0.0
  38                 1.160     9.360      0.0
  39                 2.340     9.640      0.0
  40                 3.520     9.920      0.0
*END

 0 INPUT ERRORS DETECTED

*START
SURFACE STATION=13893    YEAR OF SURFACE DATA=64    UPPER AIR STATION=13897    YEAR OF UPPER AIR DATA=64
*********************************************************************************
******************NOTE:  LEAP YEAR DAY IS MISSING*******************
*********************************************************************************
```

```
MULTIMAX AIR DISPERSION PROGRAM         SHELL OIL COMPANY           06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION
THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED

COMPUTATIONAL OPTIONS SELECTED:

    CLASSICAL PLUME EQUATION USED
    RECEPTORS ON PLANE: ALL RECEPTOR HEIGHTS SET EQUAL TO ZERO
    WIND SPEED INPUT ADJUSTED TO SOURCE STACK HEIGHTS BY POWER LAW
    RESULTS BASIS TURNER'S SIGMAS (NOT CORRECTED TO ONE HOUR BY POWER LAW)
    STABILITY CLASS LIMIT USED
    RURAL MIXING HEIGHTS USED
    RESULTS NOT ADJUSTED BY CALIBRATION EQUATION.
---NOTE:  TALL STACK APPROXIMATION AND THE CLASSICAL PLUME
EQUATION GIVE THE SAME RESULTS FOR PLANE RECEPTORS.---
TRAJECTORY PLUME RISE USED
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          08/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

HIGHEST ANNUAL AVERAGES CONCENTRATIONS FOR EACH RECEPTOR
   (IN DESCENDING ORDER)

 RANK   RECEPTOR  UG/M**3

   1       28     1.637
   2       30     1.467
   3       14     1.243
   4       32     1.222
   5       29     1.132
   6       31     1.094
   7       16     1.079
   8       13     1.074
   9       21     1.070
  10       15     1.057
  11        5     1.046
  12       27     1.032
  13       12     1.032
  14       26     1.011
  15       11     1.008
  16       37     1.000
  17       36     .9090
  18       38     .8049
  19       33     .7854
  20        4     .7767
  21       35     .7636
  22        1     .7595
  23        2     .7562
  24        3     .7533
  25       34     .7489
  26       17     .7380
  27       18     .6995
  28       10     .6963
  29        6     .6934
  30       22     .6724
  31       25     .6628
  32       20     .6255
  33       19     .6099
  34       23     .5007
  35       39     .4698
  36       24     .3504
  37        9     .2963
  38        7     .2807
  39       40     .2574
  40        8     .1627
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

HIGHEST 24-HOUR AVERAGE CONCENTRATIONS FOR EACH RECEPTOR

   (IN DESCENDING ORDER)

 RANK    RECEPTOR  UG/M**3   DAY   WIND PERSISTENCE
   1          29    28.94     81       .6552
   2          26    23.64    266       .6394
   3           5    23.24    315       .8798
   4          28    22.92    312       .7554
   5          16    22.60    245       .6794
   6          32    22.49    245       .6794
   7          40    22.09    205       .4309
   8           2    21.74    150       .6666
   9          30    20.79    206       .5212
  10          15    20.39    245       .6794
  11          14    20.04    206       .5212
  12          36    19.23    136       .5100
  13          11    18.66    153       .9437
  14          13    18.58     81       .6552
  15          33    18.37    188       .7007
  16          21    17.88    128       .8500
  17           3    17.05    188       .7007
  18          10    16.79    191       .8734
  19          37    16.50     91       .7864
  20          20    16.22    335       .6260
  21          38    16.15    217       .6883
  22          18    16.00    150       .6666
  23          27    15.94    295       .6054
  24          17    15.73    150       .6666
  25          31    15.49    245       .6794
  26          25    15.04    191       .8734
  27          35    15.03    263       .7348
  28          12    14.77    266       .6394
  29          24    14.60    117       .8609
  30           4    13.83    188       .7007
  31          34    13.57    150       .6666
  32           1    12.85    188       .7007
  33          23    12.84    212       .4236
  34          39    12.70    205       .4309
  35          19    12.02    136       .5100
  36           9    11.64    168       .4907
  37          22    10.65    113       .9641
  38           6    9.724    142       .8246
  39           7    8.197    232       .6258
  40           8    7.112    185       .5709
```

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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

SECOND HIGHEST 24-HOUR AVERAGE CONCENTRATIONS FOR EACH RECEPTOR

   (IN DESCENDING ORDER)

 RANK    RECEPTOR   UG/M**3    DAY   WIND PERSISTENCE
   1        28      22.03      153       .9437
   2         5      22.02      136       .5100
   3        14      19.19      123       .9526
   4        26      18.84      140       .5748
   5        40      17.27      150       .6666
   6        30      16.77      100       .6022
   7        11      16.73      295       .6054
   8         2      16.10      188       .7007
   9        38      15.93      123       .9526
  10        32      15.42      135       .6451
  11        10      15.40      140       .5748
  12        15      15.32      280       .9526
  13        21      15.30      127       .8811
  14        37      15.10      245       .6794
  15        25      14.73      168       .4907
  16        16      14.66      333       .9321
  17        18      14.58      188       .7007
  18        13      14.44      187       .8713
  19        24      14.41      185       .5709
  20        27      14.36      282       .7413
  21        31      14.23      154       .8116
  22        12      14.20      153       .9437
  23        29      14.14      302       .9843
  24        20      13.81      150       .6666
  25        36      13.51      126       .8997
  26        39      12.51      217       .6883
  27        23      12.39      130       .6623
  28         1      12.22      150       .6666
  29        34      12.03      207       .4995
  30        19      12.01      263       .7348
  31        33      11.79      150       .6666
  32         3      11.53      150       .6666
  33         9      11.09      189       .5779
  34        17      10.88       15       .8396
  35         4      10.30      120       .5892
  36         6      8.851      314       .4635
  37        35      8.757      120       .5892
  38        22      7.827      159       .9142
  39         7      7.657      117       .8609
  40         8      6.142      228       .7943
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

HIGHEST 3-HOUR AVERAGE CONCENTRATION FOR EACH RECEPTOR

   (IN DESCENDING ORDER)

 RANK   RECEPTOR  UG/M**3    DAY  HOUR
   1        40    176.7      205   12
   2         2    164.7      150   12
   3        28    140.8      231   12
   4        37    132.0       91   11
   5         5    130.3      315   12
   6        21    128.2      128    9
   7        17    122.0      150   12
   8        29    120.6       81   12
   9        11    116.0      295   11
  10        38    115.3      281   10
  11        15    113.5      281   11
  12        16    112.9      333   14
  13        30    110.9      174    8
  14        20    110.3      150    9
  15        27    107.7      295   11
  16        26    107.6      266   15
  17        14    107.4      100   11
  18        32    106.3      333   14
  19        18    106.2      150   12
  20        24    105.8      117   11
  21        13    105.3      187   12
  22        12    102.0      242   11
  23        39    101.6      205   12
  24        25    100.2      189   14
  25        31     97.43     281   10
  26         1     96.91     150   12
  27        36     95.85     136   14
  28        10     94.20     236   11
  29        34     91.66     207   12
  30        33     88.64     150   12
  31        35     88.14     263   12
  32         3     87.13     150   12
  33        23     86.92     130   12
  34        19     82.31     263   12
  35         4     79.33     205   12
  36        22     77.90     113   11
  37         9     77.38     189   14
  38         6     70.80     314   14
  39         7     65.37     232   13
  40         8     47.03     228   10
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

SECOND HIGHEST 3-HOUR AVERAGE CONCENTRATION FOR EACH RECEPTOR

   (IN DESCENDING ORDER)

 RANK   RECEPTOR  UG/M**3   DAY   HOUR
   1       40     138.2     150    12
   2       28     129.2     242    11
   3        5     122.8     241    10
   4       38     107.9     217    12
   5       14     105.5     246     9
   6       21     104.8     208    11
   7       13     103.2      81    12
   8       37     99.61     281    10
   9       16     98.67     245    14
  10       26     98.15     173    10
  11       11     96.31     281    13
  12       25     96.01     168    11
  13       18     95.25     207    12
  14       32     92.25     245    13
  15       12     88.37     243    15
  16       39     88.14     217    12
  17       10     88.05     190    12
  18       24     87.82     185    10
  19       30     87.05     100    11
  20       34     86.84     150    11
  21        2     86.00     188    10
  22       17     85.19      15    10
  23       36     84.00     257    12
  24       27     83.89     282     9
  25       29     83.87     302    12
  26       33     82.93     188    10
  27        3     82.56      15    10
  28       15     81.97     243     9
  29        1     80.13     257     9
  30       19     77.81     150     9
  31       20     77.57     257    12
  32       31     74.83     243     9
  33        9     73.90     168    11
  34       23     70.68     165    15
  35       35     68.92     297    14
  36        6     65.75     142    13
  37        4     63.96     150    12
  38       22     62.26     247    16
  39        7     60.49     117    11
  40        8     43.92     185    10
```

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MULTIMAX AIR DISPERSION PROGRAM         SHELL OIL COMPANY         06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

HIGHEST 1-HOUR CONCENTRATIONS FOR EACH RECEPTOR
   (SORTED IN DESCENDING ORDER)

 RANK    RECEPTOR   UG/M**3    DAY    HOUR
   1         40      451.9     205     12
   2         37      396.0      91     12
   3         38      341.7     281     10
   4         10      281.9     236     12
   5          5      277.8     241     10
   6         11      271.6     163     12
   7         23      260.8     130     12
   8         39      246.1     205     12
   9         21      242.0     158     13
  10          1      240.2     257     10
  11         13      239.0     310     12
  12          4      238.0     205     12
  13         26      235.9     173     10
  14         24      218.8     167     15
  15         28      217.4     242     11
  16         16      211.1     245     14
  17         27      207.3     242     10
  18          2      203.5     150     12
  19         20      201.4     150     10
  20         17      198.5     146     11
  21         25      198.4     228     13
  22         19      198.1     150      9
  23         12      191.7     162     10
  24          7      191.4     232     14
  25         18      189.9     207     13
  26          6      189.2     314     14
  27         35      187.4      26     13
  28         29      182.7      81     10
  29         15      179.6     281     12
  30         14      178.6     246      9
  31         32      176.3     124     15
  32         31      158.1     147     17
  33         22      154.9     203     15
  34         30      152.8     240     10
  35         36      145.1     126      9
  36          3      140.8     257     10
  37         34      136.0     207     12
  38         33      133.3     362     12
  39          9      130.8     189     14
  40          8       83.78    185     11
*************************************************************************
******************NOTE:  LEAP YEAR DAY IS MISSING*******************
*************************************************************************

CALCULATIONS COMPLETED ON DAY: 365
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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION
THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED

COMPUTATIONAL OPTIONS SELECTED:

    CLASSICAL PLUME EQUATION USED
    RECEPTORS ON PLANE: ALL RECEPTOR HEIGHTS SET EQUAL TO ZERO
    WIND SPEED INPUT ADJUSTED TO SOURCE STACK HEIGHTS BY POWER LAW
    RESULTS BASIS TURNER'S SIGMAS (NOT CORRECTED TO ONE HOUR BY POWER LAW)
    STABILITY CLASS LIMIT USED
    RURAL MIXING HEIGHTS USED
    RESULTS NOT ADJUSTED BY CALIBRATION EQUATION.
---NOTE:  TALL STACK APPROXIMATION AND THE CLASSICAL PLUME
EQUATION GIVE THE SAME RESULTS FOR PLANE RECEPTORS.---
TRAJECTORY PLUME RISE USED

RECEPTOR   28    ANNU AVERAGE CONCENTRATION= 1.637

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E       NO.     PERCENT    UG/M**3     RANK
SOURCE 1                1      79.51     1.302         1
SOURCE 2                2      20.49     .3355         2
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

RECEPTOR   29    DAY  AVERAGE CONCENTRATION= 28.94
                 DAY =  81

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E        NO.    PERCENT    UG/M**3     RANK
SOURCE 1                1     94.13      27.24         1
SOURCE 2                2     5.866      1.697         2
```

```
MULTIMAX AIR DISPERSION PROGRAM         SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

RECEPTOR   28    DAY  AVERAGE CONCENTRATION= 22.03
                 DAY = 153

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E       NO.    PERCENT    UG/M**3    RANK
SOURCE 1                1    100.0      22.03         1
SOURCE 2                2    .7356E-05 .1621E-05      2
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

RECEPTOR   40    3-HO AVERAGE CONCENTRATION= 176.7
                 DAY = 205 HOUR = 12

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E      NO.    PERCENT    UG/M**3     RANK
SOURCE 1              1     85.23      150.6         1
SOURCE 2              2     14.77      26.11         2
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

RECEPTOR   40    3-HO AVERAGE CONCENTRATION= 138.2
               DAY = 150 HOUR = 12

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E       NO.    PERCENT   UG/M**3     RANK
SOURCE 1                1    100.0     138.2          1
SOURCE 2                2     .0        .0            2
```

```
MULTIMAX AIR DISPERSION PROGRAM         SHELL OIL COMPANY            06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

RECEPTOR   40    1-HO AVERAGE CONCENTRATION= 451.9
                DAY = 205 HOUR = 12

(SOURCE CONTRIBUTIONS IN DESCENDING ORDER)

    S O U R C E      NO.     PERCENT    UG/M**3     RANK
SOURCE 1               1     100.0      451.9          1
SOURCE 2               2     .0         .0             2
```

```
MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          08/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY =  81      WIND PERSISTENCE =  .655

        STABILITY  WIND SPEED,  WIND AZIMUTH,   TEMPERATURE,    MIXING HEIGHT,
HOUR      CLASS    METERS/SEC     DEGREES*       DEGREES C          METERS
  1         D         4.63         215.            5.               1101.
  2         D         3.60         184.            5.               1096.
  3         D         3.60         182.            4.               1091.
  4         D         3.60         147.            3.               1086.
  5         E         2.57         151.            2.               1081.
  6         E         3.09         185.            2.               1076.
  7         E         2.57         162.            2.                 91.
  8         D         3.60         186.            4.                226.
  9         C         4.63         218.            6.                361.
 10         C         4.63         199.            7.                496.
 11         C         5.14         188.            9.                631.
 12         B         2.57         205.           10.                766.
 13         C         5.66         198.           12.                901.
 14         C         5.14         201.           14.               1036.
 15         C         5.66         159.           16.               1036.
 16         C         4.12         203.           16.               1036.
 17         C         4.12         221.           17.               1036.
 18         D         2.06         133.           17.               1036.
 19         D         4.12           7.           13.               1035.
 20         D         3.09          44.           11.               1034.
 21         D         3.09          52.           11.               1033.
 22         D         2.06          84.           10.               1031.
 23         E         1.00          85.           10.               1030.
 24         E         1.00          82.            9.               1029.

 *  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY = 150      WIND PERSISTENCE =  .667

        STABILITY  WIND SPEED, WIND AZIMUTH,  TEMPERATURE,   MIXING HEIGHT,
HOUR      CLASS    METERS/SEC    DEGREES*      DEGREES C        METERS
   1        E         2.06         162.          17.             897.
   2        E         2.57         191.          17.             926.
   3        D         3.60         232.          17.             954.
   4        E         3.09         272.          16.             983.
   5        E         2.57         231.          16.            1012.
   6        E         3.09         266.          15.             105.
   7        D         3.60         261.          16.             251.
   8        D         5.14         314.          19.             397.
   9        C         4.12         293.          21.             542.
  10        B         3.60         308.          22.             688.
  11        B         4.63         308.          24.             834.
  12        A         2.06         275.          25.             980.
  13        A         2.57         273.          26.            1126.
  14        B         3.09         270.          29.            1272.
  15        C         2.06         275.          30.            1272.
  16        C         4.12          32.          29.            1272.
  17        C         1.00          27.          27.            1272.
  18        D         2.57         358.          27.            1272.
  19        D         3.60         232.          26.            1272.
  20        D         2.57         341.          25.            1243.
  21        D         2.57         289.          24.            1211.
  22        D         2.06         217.          23.            1180.
  23        E         3.09         224.          22.            1149.
  24        E         2.57         266.          21.            1118.

*  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY = 153      WIND PERSISTENCE =  .944

         STABILITY  WIND SPEED, WIND AZIMUTH,  TEMPERATURE,  MIXING HEIGHT,
HOUR       CLASS    METERS/SEC    DEGREES*     DEGREES C       METERS
  1          E          3.09        150.          17.          1284.
  2          E          2.06        151.          16.          1319.
  3          E          2.06        164.          16.          1354.
  4          E          3.09        150.          16.          1390.
  5          E          2.06        158.          16.          1425.
  6          E          3.09        150.          16.           146.
  7          D          3.09        155.          16.           346.
  8          C          4.63        176.          19.           545.
  9          B          3.60        162.          21.           745.
 10          C          4.63        188.          24.           945.
 11          C          5.14        179.          25.          1145.
 12          B          4.12        200.          26.          1344.
 13          C          5.14        194.          26.          1544.
 14          B          3.60        175.          27.          1744.
 15          C          4.12        160.          29.          1744.
 16          C          5.14        225.          29.          1744.
 17          C          4.12        183.          29.          1744.
 18          C          4.12        178.          29.          1744.
 19          D          5.14        179.          27.          1744.
 20          D          2.57        185.          24.          1750.
 21          D          3.60        176.          24.          1758.
 22          D          3.60        178.          22.          1765.
 23          D          3.60        204.          21.          1772.
 24          D          3.09        203.          21.          1779.

*  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

METEOROLOGICAL DATA FOR DAY = 205      WIND PERSISTENCE =  .431

       STABILITY  WIND SPEED, WIND AZIMUTH,  TEMPERATURE,    MIXING HEIGHT,
HOUR     CLASS    METERS/SEC    DEGREES*      DEGREES C         METERS
  1        E         2.57          83.           24.            1197.
  2        D         4.12          92.           23.            1204.
  3        D         2.06          90.           22.            1212.
  4        D         3.09          91.           22.            1219.
  5        D         3.09         124.           22.            1226.
  6        E         3.09         124.           23.            1233.
  7        D         3.09         135.           24.            1241.
  8        C         3.60         158.           26.            1248.
  9        C         4.12         144.           28.            1255.
 10        B         3.09         138.           29.            1262.
 11        B         4.12         182.           31.            1269.
 12        A         2.57         264.           31.            1277.
 13        B         3.09          74.           31.            1284.
 14        C         2.57         355.           31.            1291.
 15        D         5.14          57.           26.            1291.
 16        D         3.09          86.           26.            1291.
 17        D         2.06         230.           25.            1291.
 18        C         1.00         229.           26.            1291.
 19        D         3.09         359.           26.            1291.
 20        D         4.12         204.           26.            1271.
 21        D         2.06         158.           25.            1248.
 22        D         2.57         233.           24.            1225.
 23        D         3.60         194.           24.            1202.
 24        C         2.57         319.           23.            1179.

*  WIND AZIMUTH IS DEGREES TOWARDS WHICH WIND IS BLOWING, CLOCKWISE FROM NORTH.
********************************************************************************
******************NOTE:  LEAP YEAR DAY IS MISSING*******************
********************************************************************************

SELECTED TIMES - RECEPTOR CALCULATIONS  COMPLETED ON DAY= 205
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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION
THIS RUN IS FOR 2 SOURCES AND 40 RECEPTORS
NO OPTIONS SPECIFIED -- ALL DEFAULT VALUES USED

COMPUTATIONAL OPTIONS SELECTED:

    CLASSICAL PLUME EQUATION USED
    RECEPTORS ON PLANE: ALL RECEPTOR HEIGHTS SET EQUAL TO ZERO
    WIND SPEED INPUT ADJUSTED TO SOURCE STACK HEIGHTS BY POWER LAW
    RESULTS BASIS TURNER'S SIGMAS (NOT CORRECTED TO ONE HOUR BY POWER LAW)
    STABILITY CLASS LIMIT USED
    RURAL MIXING HEIGHTS USED
    RESULTS NOT ADJUSTED BY CALIBRATION EQUATION.
---NOTE:  TALL STACK APPROXIMATION AND THE CLASSICAL PLUME
EQUATION GIVE THE SAME RESULTS FOR PLANE RECEPTORS.---
TRAJECTORY PLUME RISE USED

  24-HOUR AVERAGE TOTAL CONCENTRATIONS AT EACH RECEPTOR FOR DAY  81

                          --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC.  RANK  UG/M**3          X,KM       Y,KM   AZIMUTH  RADIUS,KM     X,KM        Y,KM
   1   34 .0               -1.200      9.500    352.80     9.575
   2   33 .1413E-27        -1.200     10.200    353.29    10.270
   3   35 .0               -4.700      9.500    333.68    10.599
   4   36 .0               -4.700      8.800    331.89     9.976
   5   31 .3340E-14         1.750     14.500      6.88    14.605
   6   22 .6906E-07         3.663     14.119     14.55    14.587
   7   21 .1068E-06         5.286     13.036     22.07    14.066
   8   25 .5076E-11         6.369     11.413     29.16    13.070
   9   19 .5574E-06         6.750      9.500     35.39    11.654
  10    9 .2218             6.369      7.587     40.02     9.906
  11   10 .1964             5.286      5.964     41.55     7.969
  12    3 11.48             3.663      4.881     36.89     6.103
  13    2 18.58             1.750      4.500     21.25     4.828
  14    4 5.827            -0.163      4.881    358.08     4.883
  15   11 .1781            -1.786      5.964    343.33     6.226
  16   17 .1117E-04        -2.869      7.587    339.28     8.111
  17   37 .0               -3.250      9.500    341.11    10.041
  18   38 .0               -2.869     11.413    345.89    11.769
  19   30 .1009E-13        -1.786     13.036    352.20    13.157
  20   20 .1103E-06        -0.163     14.119    359.34    14.120
  21   23 .9014E-08         1.750     16.500      6.05    16.593
  22   13 .2650E-04         4.429     15.967     15.50    16.570
  23   15 .1612E-04         6.700     14.450     24.88    15.927
  24   24 .4758E-09         8.217     12.179     34.01    14.692
  25   14 .1934E-04         8.750      9.500     42.65    12.916
  26   18 .5336E-05         8.217      6.821     50.30    10.679
  27    6 5.114             6.700      4.550     55.82     8.099
  28    7 2.821             4.429      3.033     55.60     5.368
  29    1 28.94             1.750      2.500     34.99     3.052
  30    5 5.291            -0.929      3.033    342.97     3.172
  31    8 2.261            -3.200      4.550    324.88     5.563
  32   12 .1101E-03        -4.717      6.821    325.33     8.293
  33   39 .0               -5.250      9.500    331.07    10.854
  34   40 .0               -4.717     12.179    338.83    13.060
  35   32 .1975E-22        -3.200     14.450    347.51    14.800
```

```
36   16 .1263E-04    -0.929    15.967    356.67    15.994
37   28 .6589E-13    -0.020     9.080    353.87     9.080
38   27 .1131E-12     1.160     9.360      7.06     9.432
39   29 .2098E-13     2.340     9.640     13.64     9.920
40   26 .1194E-12     3.520     9.920     19.54    10.526
```

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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

  24-HOUR AVERAGE TOTAL CONCENTRATIONS AT EACH RECEPTOR FOR DAY 153

                        --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3         X,KM      Y,KM   AZIMUTH  RADIUS,KM     X,KM        Y,KM
   1   20 .5130E-16      -1.200     9.500    352.80     9.575
   2   22 .0             -1.200    10.200    353.29    10.270
   3   23 .0             -4.700     9.500    333.68    10.599
   4   19 .9934E-16      -4.700     8.800    331.89     9.976
   5   24 .0              1.750    14.500      6.88    14.605
   6   25 .0              3.663    14.119     14.55    14.587
   7   26 .0              5.286    13.036     22.07    14.066
   8   27 .0              6.369    11.413     29.16    13.070
   9   28 .0              6.750     9.500     35.39    11.654
  10   11 1.387           6.369     7.587     40.02     9.906
  11    2 18.66           5.286     5.964     41.55     7.969
  12    3 14.20           3.663     4.881     36.89     6.103
  13    9 2.558           1.750     4.500     21.25     4.828
  14    6 6.287          -0.163     4.881    358.08     4.883
  15   10 1.930          -1.786     5.964    343.33     6.226
  16   14 .1509E-02      -2.869     7.587    339.28     8.111
  17   21 .2302E-19      -3.250     9.500    341.11    10.041
  18   29 .0             -2.869    11.413    345.89    11.769
  19   30 .0             -1.786    13.036    352.20    13.157
  20   31 .0             -0.163    14.119    359.34    14.120
  21   32 .0              1.750    16.500      6.05    16.593
  22   33 .0              4.429    15.967     15.50    16.570
  23   34 .0              6.700    14.450     24.88    15.927
  24   35 .0              8.217    12.179     34.01    14.692
  25   36 .0              8.750     9.500     42.65    12.916
  26   13 .2206E-02       8.217     6.821     50.30    10.679
  27    4 14.10           6.700     4.550     55.82     8.099
  28    1 22.03           4.429     3.033     55.60     5.368
  29    7 6.093           1.750     2.500     34.99     3.052
  30    5 9.321          -0.929     3.033    342.97     3.172
  31    8 3.318          -3.200     4.550    324.88     5.563
  32   12 .7690E-02      -4.717     6.821    325.33     8.293
  33   37 .0             -5.250     9.500    331.07    10.854
  34   38 .0             -4.717    12.179    338.83    13.060
  35   39 .0             -3.200    14.450    347.51    14.800
  36   40 .0             -0.929    15.967    356.67    15.994
  37   17 .3363E-09      -0.020     9.080    359.87     9.080
  38   15 .6707E-09       1.160     9.360      7.06     9.432
  39   16 .3460E-09       2.340     9.640     13.64     9.920
  40   18 .2813E-11       3.520     9.920     19.54    10.526
```

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MULTIMAX AIR DISPERSION PROGRAM           SHELL OIL COMPANY           06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

     3-HO AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 205 AND HOUR 12

                         --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3          X,KM      Y,KM   AZIMUTH  RADIUS,KM     X,KM      Y,KM
   1    5 47.33           -1.200     9.500   352.80     9.575
   2   10 39.31           -1.200    10.200   353.29    10.270
   3    6 44.38           -4.700     9.500   333.68    10.599
   4    3 79.33           -4.700     8.800   331.89     9.976
   5   34 .2586E-07        1.750    14.500     6.88    14.605
   6   21 1.098            3.663    14.119    14.55    14.587
   7   22 1.086            5.286    13.036    22.07    14.066
   8   13 23.42            6.369    11.413    29.16    13.070
   9   17 7.119            6.750     9.500    35.39    11.654
  10   28 .1947E-01        6.369     7.587    40.02     9.906
  11   35 .1661E-07        5.286     5.964    41.55     7.969
  12   37 .0               3.663     4.881    36.89     6.103
  13   38 .0               1.750     4.500    21.25     4.828
  14   32 .4883E-04       -0.163     4.881   358.08     4.883
  15   24 .2906           -1.786     5.964   343.33     6.226
  16   14 14.39           -2.869     7.587   339.28     8.111
  17    9 41.89           -3.250     9.500   341.11    10.041
  18   16 9.644           -2.869    11.413   345.89    11.769
  19   23 .4153           -1.786    13.036   352.20    13.157
  20   29 .9005E-02       -0.163    14.119   359.34    14.120
  21   30 .3831E-02        1.750    16.500     6.05    16.593
  22   12 24.27            4.429    15.967    15.50    16.570
  23   25 .2601            6.700    14.450    24.88    15.927
  24   11 30.28            8.217    12.179    34.01    14.692
  25   18 4.387            8.750     9.500    42.65    12.916
  26   31 .1457E-02        8.217     6.821    50.30    10.679
  27   36 .1237E-11        6.700     4.550    55.82     8.099
  28   39 .0               4.429     3.033    55.60     5.368
  29   40 .0               1.750     2.500    34.99     3.052
  30   33 .1383E-06       -0.929     3.033   342.97     3.172
  31   26 .5551E-01       -3.200     4.550   324.88     5.563
  32   15 11.76           -4.717     6.821   325.33     8.293
  33    7 43.88           -5.250     9.500   331.07    10.854
  34   19 3.889           -4.717    12.179   338.83    13.060
  35   27 .4809E-01       -3.200    14.450   347.51    14.800
  36   20 2.756           -0.929    15.967   356.67    15.994
  37    8 42.88           -0.020     9.080   359.87     9.080
  38    4 59.77            1.160     9.360     7.06     9.432
  39    2 101.6            2.340     9.640    13.64     9.920
  40    1 176.7            3.520     9.920    19.54    10.526
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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY          06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

   3-HO AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 150 AND HOUR 12

                          --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3          X,KM      Y,KM   AZIMUTH  RADIUS,KM    X,KM       Y,KM
  1     5 96.91           -1.200     9.500    352.80     9.575
  2     1 164.7           -1.200    10.200    353.29    10.270
  3     7 87.13           -4.700     9.500    333.68    10.599
  4    10 63.96           -4.700     8.800    331.89     9.976
  5    22 .0               1.750    14.500      6.88    14.605
  6    23 .0               3.663    14.119     14.55    14.587
  7    24 .0               5.286    13.036     22.07    14.066
  8    25 .0               6.369    11.413     29.16    13.070
  9    26 .0               6.750     9.500     35.39    11.654
 10    27 .0               6.369     7.587     40.02     9.906
 11    28 .0               5.286     5.964     41.55     7.969
 12    29 .0               3.663     4.881     36.89     6.103
 13    30 .0               1.750     4.500     21.25     4.828
 14    21 .1123E-13       -0.163     4.881    358.08     4.883
 15    18 .3842E-02       -1.786     5.964    343.33     6.226
 16    14 3.961           -2.869     7.587    339.28     8.111
 17     3 122.0           -3.250     9.500    341.11    10.041
 18     4 106.2           -2.869    11.413    345.89    11.769
 19    13 11.85           -1.786    13.036    352.20    13.157
 20    17 .4066E-01       -0.163    14.119    359.34    14.120
 21    31 .0               1.750    16.500      6.05    16.593
 22    32 .0               4.429    15.967     15.50    16.570
 23    33 .0               6.700    14.450     24.88    15.927
 24    34 .0               8.217    12.179     34.01    14.692
 25    35 .0               8.750     9.500     42.65    12.916
 26    36 .0               8.217     6.821     50.30    10.679
 27    37 .0               6.700     4.550     55.82     8.099
 28    38 .0               4.429     3.033     55.60     5.368
 29    39 .0               1.750     2.500     34.99     3.052
 30    40 .0              -0.929     3.033    342.97     3.172
 31    19 .2361E-03       -3.200     4.550    324.88     5.563
 32    15 1.999           -4.717     6.821    325.33     8.293
 33     6 88.64           -5.250     9.500    331.07    10.854
 34     9 65.92           -4.717    12.179    338.83    13.060
 35    16 1.969           -3.200    14.450    347.51    14.800
 36    20 .1133E-03       -0.929    15.967    356.67    15.994
 37    12 40.52           -0.020     9.080    359.87     9.080
 38    11 56.44            1.160     9.360      7.06     9.432
 39     8 80.66            2.340     9.640     13.64     9.920
 40     2 138.2            3.520     9.920     19.54    10.526
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MULTIMAX AIR DISPERSION PROGRAM          SHELL OIL COMPANY           06/22/79

PROBLEM TITLE:

TEST RUN OF MULTIMAX -- IBM COMPATIBLE VERSION

    1-HO AVERAGE TOTAL CONCENTRATION AT EACH RECEPTOR FOR DAY 205 AND HOUR 12

                           --- REFERRED TO LOCAL ORIGIN ---------  UNIV. TRANS. MERC.
REC. RANK  UG/M**3           X,KM      Y,KM   AZIMUTH  RADIUS,KM    X,KM        Y,KM
   1    5 142.0            -1.200     9.500    352.80     9.575
   2   10 117.9            -1.200    10.200    353.29    10.270
   3    6 133.1            -4.700     9.500    333.68    10.599
   4    3 238.0            -4.700     8.800    331.89     9.976
   5   22 .0                1.750    14.500      6.88    14.605
   6   23 .0                3.663    14.119     14.55    14.587
   7   24 .0                5.286    13.036     22.07    14.066
   8   25 .0                6.369    11.413     29.16    13.070
   9   26 .0                6.750     9.500     35.39    11.654
  10   27 .0                6.369     7.587     40.02     9.906
  11   28 .0                5.286     5.964     41.55     7.969
  12   29 .0                3.663     4.881     36.89     6.103
  13   30 .0                1.750     4.500     21.25     4.828
  14   19 .1465E-03        -0.163     4.881    358.08     4.883
  15   15 .8718            -1.786     5.964    343.33     6.226
  16   11 43.18            -2.869     7.587    339.28     8.111
  17    9 125.7            -3.250     9.500    341.11    10.041
  18   13 28.93            -2.869    11.413    345.89    11.769
  19   16 .3735            -1.786    13.036    352.20    13.157
  20   20 .1182E-04        -0.163    14.119    359.34    14.120
  21   31 .0                1.750    16.500      6.05    16.593
  22   32 .0                4.429    15.967     15.50    16.570
  23   33 .0                6.700    14.450     24.88    15.927
  24   34 .0                8.217    12.179     34.01    14.692
  25   35 .0                8.750     9.500     42.65    12.916
  26   36 .0                8.217     6.821     50.30    10.679
  27   37 .0                6.700     4.550     55.82     8.099
  28   38 .0                4.429     3.033     55.60     5.368
  29   39 .0                1.750     2.500     34.99     3.052
  30   21 .4149E-06        -0.929     3.033    342.97     3.172
  31   17 .1665            -3.200     4.550    324.88     5.563
  32   12 35.27            -4.717     6.821    325.33     8.293
  33    7 131.7            -5.250     9.500    331.07    10.854
  34   14 11.67            -4.717    12.179    338.83    13.060
  35   18 .1509E-01        -3.200    14.450    347.51    14.800
  36   40 .0               -0.929    15.967    356.67    15.994
  37    8 128.6            -0.020     9.080    359.87     9.080
  38    4 168.4             1.160     9.360      7.06     9.432
  39    2 246.1             2.340     9.640     13.64     9.920
  40    1 451.9             3.520     9.920     19.54    10.526
*STOP
```

```
MULTIMAX -- NORMAL END
```

## 15. COMPUTER PRODUCT ABSTRACT

### References

1. Original Univac 1110 version:

   User's Manual - "MULTIMAX: An Air Dispersion Program for Multiple Sources, Receptors and Concentration Averages", J. H. Moser, Shell Development Co., P. O. Box 1380, Houston, Texas, 77001, December 1977. (Includes additional errata and information sheets.)

2. Additional Documentation for IBM-Compatible Version of MULTIMAX (Documented by Tennessee Valley Authority.)

MULTIMAX 5/31/79

Erratum:

In the User's Manual for program MULTIMAX ("MULTIMAX: An Air Dispersion Program for Multiple Sources, Receptors and Concentration Averages", J. H. Moser, Shell Development Co., P. O. Box 1380, Houston, Texas, 77001, December 1977), a page further describing the equations for plume rise under stable conditions was inadvertently left out. Therefore, for page 17 of the Manual, please insert the following after equation 17:

Calculate

$$\Delta H_2 = \frac{5F^{1/4}}{\rho^{3/8}} \qquad (17b)$$

Set $\Delta H_f$, the final stable plume rise, to the lesser of $\Delta H$ and $\Delta H_2$.

The distance to final rise under stable conditions is:

$$x_f = \frac{3.14u}{\rho^{1/2}} \qquad (17c)$$

Use equation (17) or (17b) if the downwind distance, x, is greater than $x_f$. Otherwise, use equation 5.

Note that subroutine BEHO72, taken from EPA's UNAMAP tape, is used to compute the plume rise according to the preceding equations.

# ADDITIONAL DOCUMENTATION

# for

# IBM-COMPATIBLE VERSION OF MULTIMAX

NAME: MULTIMAX

DIVISION AND BRANCH

Division of Natural Resources Services, Air Quality Branch

RESPONSIBLE PROGRAMMER

Jerry W. Condrey, River Oaks Building, Muscle Shoals, Alabama

## General Information

The MULTIMAX dispersion model was developed by the Shell Oil Company and bought by TVA. TVA received the model in late September 1978, in the UNIVAC FORTRAN. The program has been converted to run on TVA's IBM computing system.

The UNIVAC version contained statements whose function was to save the problem definition and results to date for restarting of the program if it could not completely execute in the time allowed on Shell's computer. The IBM version does not allow for saving the status or restarting since TVA's IBM system does not permit the extensive communication between program and system permitted at Shell. Some options specified in the manual provided with MULTIMAX are associated with restarting so are not available (but should not be needed) with the IBM version. Available options can be noted under Card Input for MULTIMAX.

## File Information

Most files associated with the UNIVAC version of MULTIMAX have been eliminated. Necessary files are:

FT09F001 - A year of meteorological data compatible with EPA's CRSTER model. The file should be unformatted, with DCB=(LRECL=688,RECFM=VBS, BLKSIZE=4132) except other blocksizes may be acceptable as long as they are compatible with the logical record length.

FT06F001 - A standard printer file.

FT05F001 - Card input file.

For card input, note that options and other input are often specified in plain English. Information in quotes should be entered exactly as indicated, without the quotes. Note that such input is associated with a format of (A) without a length specification. In these instances, the length will not be of concern to the user as long as data is entered into the correct columns.

## Additional Requirements

MULTIMAX runs in 300K bytes of Core. CPU time is a function of the number of sources and number of receptors being considered and the options specified. Also, CPU time will vary greatly from computer to computer. On the IBM 370/65 computer, about 200 CPU seconds were required to run 17 sources and 15 receptors when TALL STACK APPROXIMATION, FINAL PLUME RISE, and PRINT MET STATISTICS were the options specified. The run was for 366 days.

NOTE: The MULTIMAX model was developed by J. H. Moser of the Chemical Engineering Department, Shell Development Company, a division of Shell Oil Company.

## Card Input for MULTIMAX

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| 1 | 1-14 | 'IDENTIFICATION'<br>Begins identification paragraph. Indicates that identification information follows. | (A) |
| 2 | 1-80 | Identification information to be printed. Card 2 may be repeated up to 20 times. The first will be used for printing the problem description heading. | (A) |
| 3 | 1-3 | 'END'<br>Ends identification paragraph. | (A) |
| 4 | 1-7 | 'OPTIONS'<br>Begins options paragraph. Indicates that options will follow. The options paragraph (cards 4-25) may be omitted if only defaults are to be used. Option cards (5-24) may be supplied in any order. | (A) |
| 5 | 1-9 | 'CALIBRATE'<br>Apply the calibration formula $\chi_{out} = A\chi_{mod} + B$ where $\chi_{mod}$ is the modeling calculations, $\chi_{out}$ the concentrations to be output, and A and B the coefficients explained below. If the option is not specified, no adjustment will be made to $\chi_{mod}$ for output. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 11-20 | The slope (A) in the calibration equation. | (F10.0) |
| | 21-30 | The background or Y intercept (B) in the calibration equation. | (F10.0) |
| 6 | 1-10 | 'HIGH PRINT'<br>Print concentration information of each type only for as many highest receptors as indicated. If not specified, highest concentrations at each receptor will be printed. | (A) |
| | 11-20 | The number of highest receptors at which concentrations should be printed. | (F10.0) |
| 7 | 1-9 | 'NO ANNUAL'<br>Suppress annual average calculations. By default, they are done. | (A) |
| 8 | 1-9 | 'NO 3 HOUR'<br>Suppress 3-hour average calculations. By default, they are done. | (A) |
| 9 | 1-23 | 'NO SOURCE CONTRIBUTIONS'<br>Do not perform the source contribution calculations after the yearly maxima computations. By default, this is done (if there is more than one source). | (A) |
| 10 | 1-17 | 'WIND SPEED ADJUST'<br>Assume the meteorological input data was recorded at the indicated level rather | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | than the 7-meter default. Wind speed data will be extrapolated by a power law formula based on stability class whether this card is included or not, unless card 11 is included, so the only purpose for including it should be to change the data recording level. | |
| | 21-30 | Height of measured wind speed in meters. | (F10.0) |
| 11 | 1-20 | 'NO WIND SPEED ADJUST'<br>Don't extrapolate wind speed. (Assume wind speed the same at all levels). | (A) |
| 12 | 1-25 | 'DO SAMPLE TIME CORRECTION'<br>Use the power law correction from the 10 minute to the 1 hour sampling time basis. By default, this is not done. | (A) |
| 13 | 1-20 | 'URBAN MIXING HEIGHTS'<br>Use the urban mixing height data from the meteorological data file. By default, the rural mixing heights are used. | (A) |
| 14 | 1-18 | 'RECEPTORS AS INPUT'<br>Receptor heights used exactly as input. By default, receptors will be on a plane. | (A) |
| 15 | 1-14 | 'RECEPTORS MOD1'<br>Let $Z_{in}$ = receptor elevation input minus the stack base plane elevation input. Then $Z_{mod} = Z_{in} /2$ and is limited to be less than | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | or equal to the physical stack height minus 10 meters ($Z_{mod}$ will be the elevation actually used in the modeling computations).<br>Same default as for card 14. | |
| 16 | 1-14 | 'RECEPTORS MOD2'<br>Same as for MOD1 except $Z_{mod}$ will be limited to be less than or equal to the effective plume height minus 10 meters.<br>Same default as for card 14. | (A) |
| 17 | 1-24 | 'TALL STACK APPROXIMATION'<br>Use the tall stack approximation to the Classical Gaussian Plume model. By default, the Classical Plume Equation will be used. | (A) |
| 18 | 1-17 | 'NO RECEPTOR PRINT'<br>Suppress print of receptor descriptions. By default, these descriptions are printed. | (A) |
| 19 | 1-17 | 'NO MET DATA PRINT'<br>Suppress meteorological data print for highest average concentration days. This data is printed by default. | (A) |
| 20 | 1-16 | 'ELEVATION METERS'<br>Indicates that the elevations input on ORIGIN and RECEPTORS cards are in meters. By default, these elevations are assumed to be in feet. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| 21 | 1-14 | 'ELEVATION FEET'<br>Indicates that the elevations input on the ORIGIN and RECEPTORS cards are in feet. This is the default so this card is never really necessary. | (A) |
| 22 | 1-39 | 'NO SELECTED TIME PERIODS--ALL RECEPTORS'<br>Do not perform the all receptors--selected times calculations after the yearly maxima computations. By default, this is done. | (A) |
| 23 | 1-24 | 'NO STABILITY CLASS LIMIT'<br>Stability class will be used as read from the meteorological data file. By default, stability class will not be permitted to vary by more than one class per hour. | (A) |
| 24 | 1-16 | 'FINAL PLUME RISE'<br>Use final plume rise. By default, trajectory plume rise will be used. | (A) |
| 25 | 1-3 | 'END'<br>Ends options paragraph | (A) |
| 26 | 1-4 | 'DATA'<br>Begins data paragraph. Indicates that source and receptor information follows. | (A) |
| 27 | 1-6 | 'ORIGIN'<br>The geodetic origin of the land area for which the modeling will be performed is being specified. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 11-20 | X cartesian coordinate of geodetic origin (in kilometers). | (F10.0) |
| | 21-30 | Y cartesian coordinate of geodetic origin ( in kilometers). | (F10.0) |
| | 31-40 | The elevation of the stack base plane above mean sea level (in meters or feet, depending on option--see cards 20-21). If both X and Y are input as 0, only a local reference point of 0 is used. The elevation is ignored unless either card 14, 15, or 16 is included. | (F10.0) |
| 28 | 1-7 | 'SOURCES'<br>Source information follows. From 1 to 100 sources may be specified. 2 cards (29-30) per source. | (A) |
| 29 | 1-12 | Source Description | (A) |
| | 21-25 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |
| | 26-30 | Blank for polar case. 'LOCAL' or 'UTM' for cartesian. If left blank for cartesian the ORIGIN card will be looked at and if X and Y were both input as 0.0, 'LOCAL' is assumed--otherwise 'UTM' (universal Transverse Mercator System) is assumed. Left justify. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 31-40 | Radius length to point if polar--X coordinate for point if cartesian. Always in kilometers. | (F10.0) |
| | 41-50 | Azimuth value for point in degrees if polar--y coordinate for point in kilometers if cartesian. | (F10.0) |
| | 51-55 | 'FLARE' if a flare or burning stack--otherwise blank. | (A) |
| | 61-70 | Heating rate in kcal/sec for flare stack--otherwise blank. | (F10.0) |
| 30 | 21-30 | Stack height (meters) | (F10.0) |
| | 31-40 | Stack diameter (meters) | (F10.0) |
| | 41-50 | Stack gas exit velocity (m/sec) | (F10.0) |
| | 51-60 | Stack gas temperature ($^{o}$K) | (F10.0) |
| | 61-70 | Pollutant emission rate (gm/sec) | (F10.0) |

Repeat cards 29 and 30 for all sources.

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| 31 | 1-6 | 'ENDEND'<br>Ends input of sources. | (A) |
| 32 | 1-9 | 'RECEPTORS'<br>Receptor information follows. From 1 to 300 receptors may be specified. 3 types of cards may be used to define the receptors and may appear in any order. Only POINT cards (card 33) may be used for nonzero receptor heights. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | CIRCLE cards (card 34) and LINE cards (card 35) may be used as well as POINT cards to define receptors on a plane. | |
| 33 | 1-5 | 'POINT' | (A) |
| | 11-15 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |
| | 16-20 | Blank for polar cases. 'LOCAL' or 'UTM' for cartesian. See card 29, column 26-30 for default rules. Left justify. | (A) |
| | 21-30 | Radius length to receptor point if polar--X coordinate for point if cartesian. Always in kilometers. | (F10.0) |
| | 31-40 | Azimuth value for point in degrees if polar--Y coordinate for point in kilometers if cartesian. | (F10.0) |
| | 41-50 | Elevation of receptor above mean sea level (in feet or meters depending on option--see cards 20-21). Also, note the relation to the elevation specified on the ORIGIN card (card 27). | (F10.0) |
| 34 | 1-6 | 'CIRCLE' | (A) |
| | 11-15 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 16-20 | Blank for polar cases. 'LOCAL' or 'UTM' for cartesian. See card 29, column 26-30 for default rules. Left justify | (A) |
| | 21-30 | Radius length to center of circle if polar--X coordinate for center of circle if cartesian. Always in kilometers. | (F10.2) |
| | 31-40 | Azimuth value for center of circle in degrees if polar--Y coordinate for center of circle in kilometers if cartesian. | (F10.2) |
| | 41-50 | Radius of circle in kilometers. | (F10.2) |
| | 51-60 | Number of points on circle or arc. | (F10.2) |
| | 61-70 | Degrees for first receptor point on circle or arc. | (F10.2) |
| | 71-80 | Degrees between each receptor point on circle or arc. | (F10.2) |
| | | Note: This card defines the number of receptors indicated in columns 51-60. This number, not one, is charged against the 300 maximum. | |
| 35 | 1-4 | 'LINE' | (A) |
| | 11-15 | 'POLAR' or 'P' for polar description--'CART' or 'C' for cartesian. Defaults to 'C' if blank. Left justify. | (A) |
| | 16-20 | Blank for polar cases. 'LOCAL' or 'UTM' for cartesian. See card 29, column 26-30 for default rules. Left justify. | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 21-30 | Radius length to starting receptor point on the line if polar--X coordinate for this point if cartesian. Always in kilometers. | (F10.2) |
| | 31-40 | Azimuth value for starting receptor point on the line in degrees if polar--Y coordinate for this point in kilometers if cartesian. | (F10.2) |
| | 41-50 | Radius length to last receptor point on the line if polar--X coordinate for this point if cartesian. Always in kilometers. | (F10.2) |
| | 51-60 | Azimuth value for last receptor point on the line in degrees if polar--Y coordinate for this point in kilometers if cartesian. | (F10.2) |
| | 61-70 | Number of receptor points on the line.<br>Note: This card defines the number of receptors indicated in columns 61-70. This number, not one, is charged against the 300 maximum. | (F10.2) |
| 36 | 1-3 | 'END'<br>Ends DATA paragraph. | (A) |
| 37 | 1-5 | 'START'<br>Calculate concentrations for the full year at all receptors considering all sources. | (A) |
| 38 | 1-29 | 'ALL RECEPTORS--SELECTED TIMES'<br>Indicates that the cards which follow specify types of averages and time periods for concentration calculations at all receptors. This feature is optional and cards 38-40 should be omitted if it is not being used. If desired, | (A) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | | it may be used independently of the yearly maxima calculations. | |
| 39 | 1-6 | Type of average: 'ANNUAL', 'DAY', '3-HOUR', or '1-HOUR'. Left justify. | (A) |
| | 21-30 | Day number. Does not apply to annual averages. | (F10.0) |
| | 31-40 | Hour number. Does not apply to annual or daily averages. For 3-hour averages, refers to the first hour of the triad.<br>Card 39 may be repeated up to 19 times. | (F10.0) |
| 40 | 1-3 | 'END'<br>Ends input of specification cards for all receptors-~~r~~selected times. | (A) |
| 41 | 1-29 | 'SELECTED SOURCE CONTRIBUTIONS'<br>Indicates that the cards which follow specify types of averages, receptor numbers, and time periods for source contribution calculations. This feature is optional and cards 41-43 should be omitted if it is not being used. If desired, it may be used independently of the yearly maxima calculations. | (A) |
| 42 | 1-6 | Type of average: 'ANNUAL', 'DAY', '3-HOUR', or '1-HOUR'. Left justify. | (A) |
| | 11-20 | Receptor number. | (F10.0) |
| | 21-30 | Day number. Does not apply to annual averages. | (F10.0) |

| Card No. | Column No. | Input Description | Format |
|---|---|---|---|
| | 31-40 | Hour number. Does not apply to annual or daily averages. For 3-hour averages, refers to the first hour of the triad. | (F10.0) |
| | | Card 42 may be repeated up to 57 times. | |
| 43 | 1-3 | 'END'<br>Ends input of specification cards for selected source contributions. | (A) |
| 44 | 1-14 | 'PRINT MET FILE'<br>Print meteorological data file plus statistical information on the data in the file. Omit this card if such output is not desired. | (A) |
| 45 | 1-25 | 'PRINT MET STATISTICS ONLY'<br>Output only statistical information on the meteorological data--not the data itself. Omit this card if such output is not desired. | (A) |
| 46 | 1-4 | 'STOP'<br>Terminates run of MULTIMAX. | (A) |